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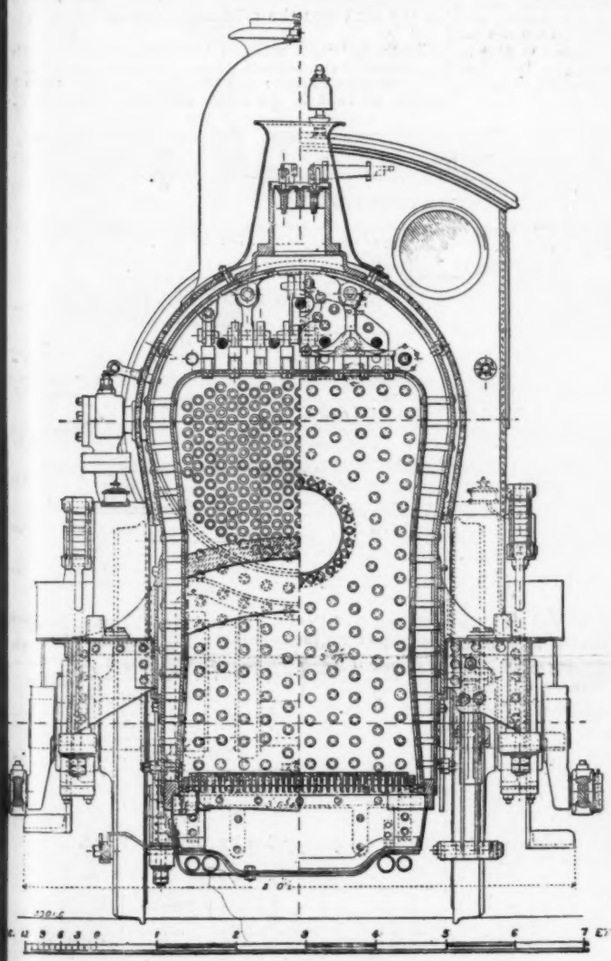
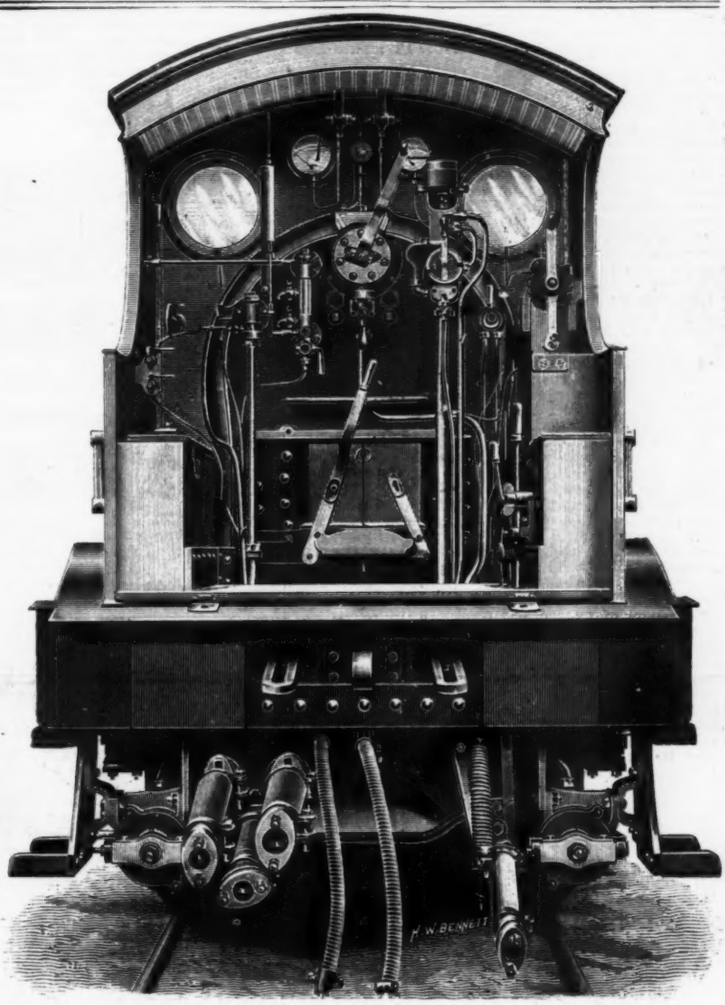
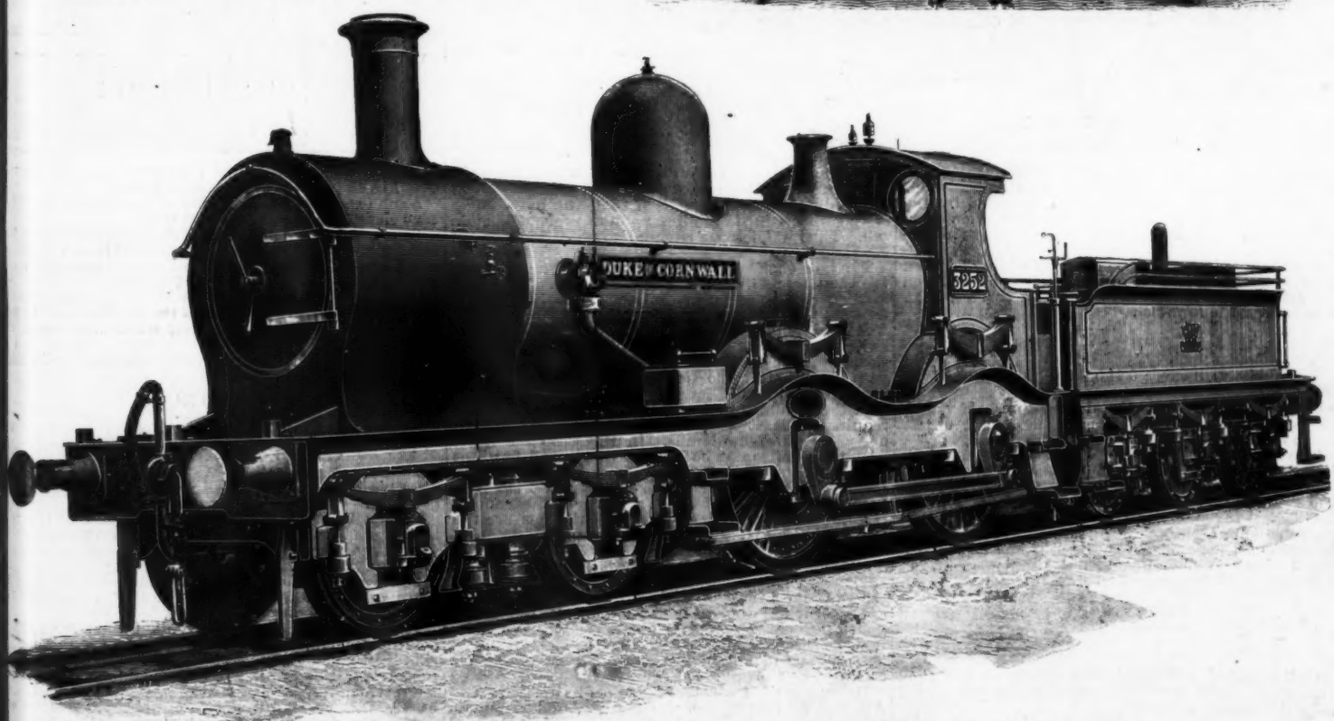






ENGLISH EXPRESS LOCOMOTIVE FOR HEAVY GRADES. (SPECIALLY BUILT FOR THE HAMBURG-AMERICAN MAIL SERVICE.)

AN ENGLISH EXPRESS PASSENGER LOCOMOTIVE FOR HEAVY GRADES.

THE powerful express locomotive of which we present three views, a perspective view, a cross section through the firebox, and an end view looking into the cab, is indirectly the outcome of the keen competition existing in the trans-Atlantic steamship trade, and more particularly of that existing between the American and the Hamburg-American steamship lines. These two companies have hitherto used the same port—Southampton—for landing the English mails, where they were transferred to the cars for the 100-mile run up to London. With a view to quickening its service, the Hamburg-American Company has recently changed its port of call from Southampton to Plymouth, which lies a little over 200 miles to the westward by water. The distance by rail to London from the latter port is about 250 miles, or 150 miles greater than from Southampton. The difference in time occupied by the mail train and the steamer over this 150 miles should approximately represent the gain in time made by the adoption of the Plymouth-London route.

The Great Western Railway is making strenuous efforts to reduce their running time over this route to the lowest possible limit, and to this end they have built two special types of express engines, one with large single driving wheels, for use on the level portions of the road, and the other for the very hilly and crooked portion of the line between Exeter and Plymouth. It is the latter type which is herewith shown, our illustrations being reproduced from London Engineering. The results thus far have been very gratifying, so much so that the Great Western Railway can claim to be now running the fastest long-distance regular train in the world, the running time being a little over 55 miles per hour.

On the first run of the new service the train, weighing 180 tons, exclusive of engine, was hauled from Plymouth to Exeter, 52 miles, by an engine of the class we illustrate, at the rate of 45·7 miles per hour; and on a later run the same distance was covered with a 122-ton train at the rate of 47·6 miles per hour. This is an excellent performance, considering that for curvature and grades this is one of the worst bits of road in all England.

It will be seen that in its general features this engine resembles the standard American eight-wheeled passenger engine. The most familiar feature is the extension smoke box, which is a novelty in English practice; although it has been for many years in use in this country, where it was adopted in place of the former spark arrester in the smokestack. This innovation, together with the leading truck (or bogie as it is called on the other side), and the four coupled drivers constitute the resemblance. In its details the engine is English, having inside cylinders, a small cab, the customary six wheeled tender, and the plate frame. In this case, the frame is double, there being a plate on the outside as well as on the inside of the wheels. This arrangement accounts for the use of the extra set of cranks on the outside of the frames to carry the coupling rods. The use of double frames is peculiar to the Great Western Railway; where it is a legacy from Daniel Gooch's broadgage engines. It must be a costly construction; though, it is true, the resulting frame must be very stiff, and it allows the use of four axle-boxes upon each axle. The use of Mansell wooden disk truck wheels will be noted; a good feature in the truck, also, is the provision for lateral movement under the control of springs.

The engines have cylinders 18 in. diameter by 26 in. stroke. The driving wheels are 5 ft. 7½ in. diameter—much below the average English practice, but well suited to hill climbing—and the boiler pressure is 160 pounds. The tractive force works out at 124·8 pounds per pound of mean effective pressure per square inch on the pistons. The total heating surface is 1400 sq. ft.; grate area, 19 sq. ft. The total weight of engine is 78½ tons.

An estimate, based upon the performance of the first two engines of this type during 10,000 miles of running, shows an average coal consumption of 30⅝ pounds per mile. The engines were built from the designs of Mr. William Dean, the locomotive superintendent of the Great Western Company.

THE SAND TRACK.

By ROBERT GRIMSHAW.

FROM time to time one hears of runaway locomotives and of runaway trains, both with and without motive power. The action of the wind, aided by the slippery condition of the rails, especially when they are covered with ice or half wet, aids such occurrences.

For the relation of the coefficient of sliding friction, f, to the velocity, v, in meters per second between wrought iron tires and rails with wet surface, Prof. Frank gives the formula:

$$f = 0{\cdot}24\, e^{\frac{-v}{35}}$$

e being the base of the natural logarithms. If v = 20, 25 and 35 meters respectively, f becomes 0·1355, 0·11993 and 0·090131 respectively.

The speed of 35 meters per second or 78·3 miles per hour is reached by regular trains; and doubtless without the retarding action of brakes they would reach the same velocity in going down a grade of 1 in 40. As in Germany only ¼ of the wheels of slow freight trains running over inclines of 1 in 40 have brakes and brakemen, a train which by neglect has acquired a speed of say 25 meters could not be stopped in wet weather, as the braking effect would be only

$$\frac{0{\cdot}11993}{5} = 0{\cdot}023986.$$

Galton found with steel tires sliding on wet steel rails with a speed of 88 feet or 26·82 meters per second a friction of only f = 0·027.

The stopping power of the brakes of the train with only ¼ the wheels braked would therefore be limited to

$$\frac{0{\cdot}027}{4} = 0{\cdot}00675$$

or $\frac{1}{148}$ of the weight; too little to balance the effect of gravity on a slope of 1 in 40.

So long as the contrivances for braking are not sufficient to stop fast running trains under all circumstances, there should be other means for stopping in case of emergency. It also seems desirable to provide regularly such means to the watchman on the line and to outsiders in general. There is certainly on most roads a lack of some appliance against carelessness or of accident to the engine runner.

As is known, there are in use on the English railways, for the protection of main lines, switches, throwing from the main line cars which come from sidetracks at improper times. Such switches, called "throw-offs," are connected with the signal in such a manner that the latter cannot allow the passing of a train to the main line; the throw-off switches sending it into the sand on ballast. In case of a car moving on the siding in the direction of the main line, it will be thrown off the main line in time to be stopped by the resistance of the ballast.

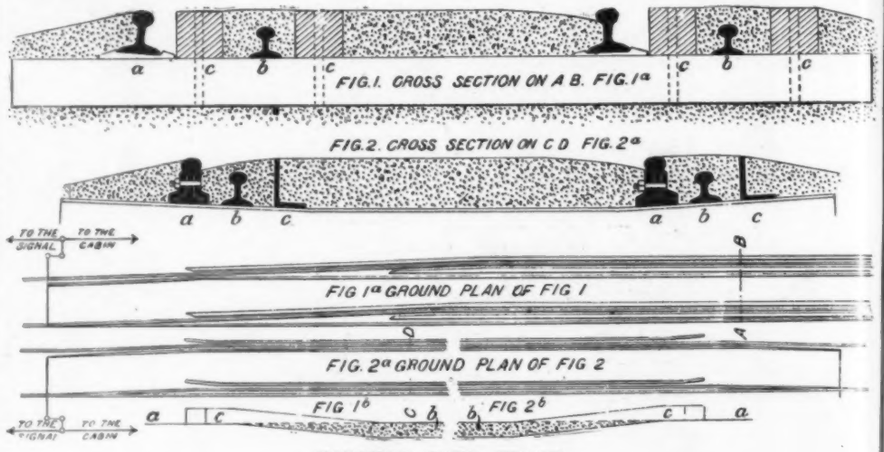


FIG. 1. CROSS SECTION ON A B. FIG. 1a
FIG. 2. CROSS SECTION ON C D FIG. 2a
TO THE SIGNAL
TO THE CABIN
FIG 1a GROUND PLAN OF FIG 1
FIG. 2a GROUND PLAN OF FIG 2
FIG 1b
FIG 2b

KOPCKE'S SAND TRACK.

This way of stopping cannot be employed for trains on main lines, because it would bring about destruction not less shocking than that which it would be intended to prevent. Therefore it is necessary to make the leaving the main rails an entirely safe measure before it can be recommended as a means of safety.

This may be done by guiding the train to be stopped, not into the ballast but on a separate track, the rails of which are covered with a layer of sand; the switch leading to this track to be coupled with the signal before which, when it stands at danger, the train should stop. A second switch may serve as an outlet into the main track to avoid backing the stopped train. This safety siding being always covered by a layer of sand, is not dependent for its efficiency on the engine runner, nor on an apparatus for strewing sand, nor on the watchman for throwing impediments on the rails.

The arrangement here described, which is the invention of Prof. C. Kopcke, of Dresden, Germany, is illustrated in two different arrangements, both in the form of loop tracks. The rails of the sand track are at such a slight distance from the main track that no frogs are required. Figs. 1 and 2 are cross sections. Figs. 1a and 2a plans, Figs. 1b and 2b lengthwise sections with the heights exaggerated tenfold.

In order to use the sleepers of the main track also for the sand track, the rails of the latter are enough lower to bring the sand layer flush with the head of the main rail. As the sand track rails sustain no noticeable wear, they may be lighter; and they require no bed plates.

In Figs. 1 and 1a is shown a track with wood ties and wooden lengthwise guard sleepers on both sides of the sand track rails. A switch leads into it from the main track. The inclination of the sand track begins at such a distance from the switch that the outer edges of the wheels in descending cannot touch the main rail. The total descent is equal to the thickness of the sand layer.

The rails of the main track are marked a; those of the sand track b; the guard sleepers c. There are four guard sleepers, c, one on each side of each sand track rail, although one pair, either inside or outside, would be enough. In the plan Fig. 1a, the entrance switch is represented open. The ends of the guard sleepers are chamfered. The connections of the switch with the signal at one side and with the box at the other are indicated.

In Figs. 2 and 2a that arrangement is shown which requires the least width, as the main rails represent one pair of the guard rails. In this case the fishes with their bolts must be flush with the rail head, as guard rails angle irons are represented. Finally in Fig. 2 bent iron cross sleepers are chosen. Beside the entrance, Fig. 2a shows an exit switch, the connections of which with the signal and the box are the same as in Fig. 1a.

Tests have been made of the effect of the sand tracks on a track having a grade of 1 in 100. Wooden guard sleepers are placed between the rails, leaving a gutter for the wheel flanges and rising five centimeters (= two inches) above the level of the rails. These guard sleepers serve both to secure the wheels against leaving the rails and to level the sand layer. The cars were set in motion by a shunting engine and accelerated by the grade of 1 in 100.

Before the sand covered track a distance equal to AB, Fig. 3, of 30 meters was marked, and time was taken by a chronometer beating ½ seconds. From B downward the sand layer extends. The speed found in this manner is the mean for the middle of AB; but as the track is inclined 1 in 100, there must be an increase on the lower half. Deducting the passing resistance of about 1 in 200, this increase has the value of a fall of

$$\frac{15}{200} = 0{\cdot}075 \text{ meter.}$$

Afterward the train falls through the whole height of slope through which the head of the train passes on the sand track.

To get the full energy to be annihilated by running on the sand track (in the annexed table represented as potential energy in meters of fall) there must be added to the height of velocity, v, the vis viva of the wheels.

After stopping, the cars stood between C and D, at distances, a and b, from the beginning of the sand layer. The center of gravity of the train was always nearly in the middle of length; therefore, the distance in the sand was the arithmetical mean $\frac{a+b}{2}$. The vis viva of wheel rotation is expressed most simply by reducing the rotated mass to a velocity, q, moving at the circumference; and the value of that mass is added to that of the entire mass, Q. Then the coefficient, f, of the braking action of the sand track will be found from the equation:

$$Qf\frac{a+b}{2} = Q\left(0{\cdot}075m + \frac{b}{100}\right) + \frac{Q+q}{g}\frac{v^2}{2}; \text{ giving}$$

$$f = \frac{0{\cdot}075 + \frac{b}{100} + \frac{Q+q}{g}\frac{v^2}{2}}{\frac{a+b}{2}};$$

g being the acceleration by gravity = 9·81m.

TABLE OF RESULTS OF TRIALS.

No.	No. of cars.	Percentage of wheels.	Velocity, meters per second.	Distance in sand, in meters. a	Distance in sand, in meters. b	Potential energy.	Coefficient of resistance.
1	2 empty	16	3·75	7	17·6	1·082	0·0880
2	8 empty	16	5·882	13·6	72·0	2·841	0·066
3	10 loaded	5·3	7·692	45·0	117·2	4·422	0·0543
4	10 loaded, 3 empty	6	8·823	30·4	180·6	5·638	0·0675
5	9 loaded	5·3	10·0	78·2	142·6	6·870	0·0622
6	9 loaded	5·3	12·5	101·0	165·0	10·113	0·0569

The thickness of the sand layer was 5 cm. for numbers 1 to 4 and 8 cm. for numbers 5 and 6.

As an example of the manner of calculation of the coefficient, we may use the first trial.

Example: The empty cars with the velocity of 3·75 meters per second came to a standstill after having run in the sand track with the first axle a distance of 17·6 meters, with the last one 7 meters; the mass of the rotating parts considered as at the circumference of the wheels was 16 per cent. of the entire mass of the cars (axles and wheels included); what was the friction?

Solution: By substituting the given numbers in the equation we get

$$f = \frac{0{\cdot}075 + \frac{17{\cdot}6}{100} + \frac{1{\cdot}16 \times 3{\cdot}75^2}{2 \times 9{\cdot}81}}{\frac{7 + 1{\cdot}7 \times 6}{2}} = \frac{1{\cdot}082}{12{\cdot}3}; \quad f = 0{\cdot}088.$$

From all the trials it has been proved that the retardation in the sand track is quite continuous and without any jerk. The buffers are pressed in gradually, and there was never remarked any tendency to lift an empty car placed between loaded ones, although there was often, by reason of the load, considerable difference of height of the buffers.

The resistance of the sand diminishes with the length of train, the first wheels finding more resistance than the following. Nevertheless, after the repeated passing of wheels the remaining sand layer has a strong resistance, the average being not less than 0·0543.

Also the resistance seems to increase with the ve

locity, and in a small degree with the thickness of the sand layer.

The sand was clear white river sand, forming under the wheels cakes of but loose coherence. Pit sand gives consistent cakes, but also answers for the work.

Tests were also made during a cold spell with 10° below zero Centigrade (= + 14° F.) The sand layer of 8 cm. thick was frozen after having been sprinkled, forming a middling solid mass. Under these circumstances the sand track worked well, as the cars (7 empty and 1 loaded) ran into it without dangerous acceleration. The first axle compressed the sand layer to about 4 cm.; the last one to 2 cm., the sand giving way sidewise and finally forming a cake in which even the finer grains were partly crushed. As the track is well drained, the sand showed only a slight crust, and it was necessary to loosen and then moisten it, in order to get a frozen mass.

On the Saxon State Railway sand tracks have been laid for several purposes. The shunting station at Dresden-Friedrichstatt has inclined tracks about 1¼ miles long; the cars are all separated as well as collected again by running down by gravity in the same way as at Edgehill, near Liverpool, planned by Mr. Footner.

As it might be that an unbraked car would run away, a self-acting contrivance is necessary to stop it, and for this purpose sand tracks have been laid.

Another application has been made on the incline of 1 in 55 before the passenger station at Dresden-Neustadt. Here a connection with the signal has been effected, so that when the signal shows danger, the train, if proceeding in spite of warning, will be directed into the open switch of the sand track, and thus effectually, although safely, stopped.

The application of sand tracks has given rise to such problems as this:

How long must a sand track be, with an inclination of 1 in 100, to be able to stop a car coming down a track of regular incline 350 meters long, when the resistance, before coming into the sand, is 1 in 400?

Solution: Ten cars have a wheel base of about 72 meters; the train will acquire a vis viva equivalent to a fall of 350 (0·01 — 0·0025) = 2·625 meters, to which is to be added the fall of half the length of train = $\frac{36}{100}$; so that the whole energy to be annihilated by the sand track is 2·985 meters.

The coefficient of resistance after deduction of the action of gravity on the inclined track being 0·0543 — 0·01 = 0·0443, the required length is $\frac{2{\cdot}985}{0{\cdot}0443}$ = 67·4 meters.

To this is to be added half the length of the train, so the entire length of the track becomes 67·4 + 36 = 103·4 meters.

As 350 meters is the greatest distance in which a car may be left to the action of gravity when out of control, the length of 103·4, or say 105 meters, will be sufficient at the Dresden shunting station.

For stopping a car running with a velocity of 25 meters per second, the distance on the level sand track would be, according to test No. 6 of the table (the car being loaded) $\frac{1{\cdot}053 \times 25^2}{19{\cdot}62 \times 0{\cdot}076}$ = 441 meters.

THE LADY WINDSOR NEW DEEP LOCK, BARRY DOCKS, ENGLAND.

WE present an engraving, for which we are indebted to the Engineer, of the deepest lock in the world. It forms part of the very extensive works which are now nearing completion at Barry Dock, which is situated on the Welsh side of the Bristol Channel. These works, which are being carried out under the direction of Mr. John Wolfe Barry, C.B., "have converted an almost barren island into a great shipping port, with an export of about 2,500,000 tons, carried in the largest vessels. The population of the district has grown in eleven years from a few dozens to about 20,000." The following description is taken from the Proceedings of the Institution of Civil Engineers.

General Description.—The works comprise a tidal basin of seven acres, a dock of seventy-three acres at the top of the slopes and sixty-two acres at their toe, and a timber pond of twenty-four acres. There is also a graving dock belonging to a private company. Between the graving dock referred to and the entrance basin has been built the Lady Windsor deep lock, the deepest in the world, now nearly completed. The dock as originally designed had a water area of forty acres; but the foundations for the south wall were set further back, in order to obtain firm ground, and the area thus increased.

The Barry Dock is designed to afford efficient accommodation for the shipment of coal from South Wales, the annual exportation of which, from Cardiff and Penarth alone during the past twenty years has risen from 3,000,000 to 11,000,000 tons. Barry Island is about one mile in length by one-half in width, and rises 120 ft. above mean sea level; and the mainland north of the dock also rises considerably. The site is therefore well sheltered, particularly from southwesterly winds, which, together with easterly winds, are the strongest in the Bristol Channel. The entrance to the dock is at the eastern end of the island under the high land of Nell's Point, which excellent natural shelter is supplemented by two outlying converging breakwaters; these protect the entrance to the south, where the "fetch" is fourteen miles, and to the southeast, with a fetch of sixteen miles. The approach to the breakwaters is free from rocks and shoals, and is also efficiently lighted. Between the heads of the breakwaters there is an opening of 350 ft. which is close to deep water. There is good anchorage ground for the largest vessels to the east of the dock, between Barry and Sully Islands, a distance of three miles.

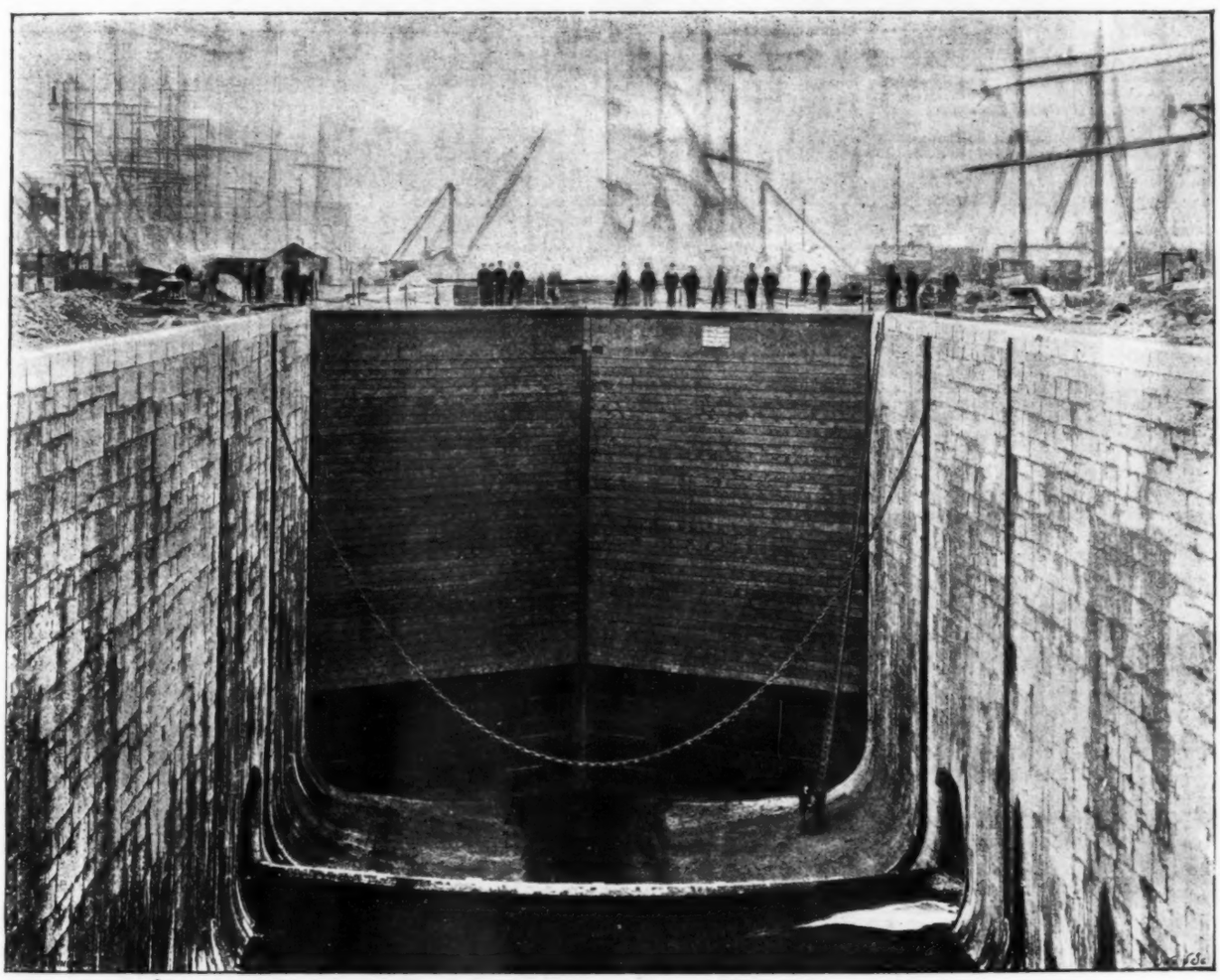
The tidal range is 36 ft. at ordinary spring tides, increasing to 40 ft. at extraordinary springs, and 19½ ft. at ordinary neap tides, diminishing to 16 ft. at extraordinary neaps.

The dock is not fed with water from any river. A channel has been dredged between the breakwater heads and the entrance to the dock to a depth of 1 ft. below the lowest part of the sills. On the seaward side of the entrance are two timber jetties 200 ft. long, with horizontal fenders along the face. The entrance is 80 ft. wide, with a single pair of wrought iron gates, and gives access to a basin 500 ft. wide and 600 ft. long. Between the basin and the dock is the passage, having also a width of 80 ft. The sides of the entrance and passage have two horizontal elm fenders for the protection of ships. The depth of water on the working part of the sills, which are curved, is as follows:

	Feet.
High water ordinary spring tides.....	37·7
Low water ordinary spring tides	1·6
High water ordinary neap tides.....	29·3
Low water ordinary neap tides..	9·7

The available depths, however, at the center of the inverts are 3 ft. more. On the west side of the entrance is a culvert having a minimum width of 10 ft., with a pair of greenheart sluices, raised and lowered by direct-acting hydraulic cylinders and pistons. There are no sluiceways through the walls of the entrance or passage; but twelve sluices, having an area of 200 square ft., are provided in the gates. In the passage is a pair of wrought iron gates, and there is a culvert on the west side 8 ft. in diameter. The culverts serve to draw down rapidly the water when the flow of water through the gate sluices becomes slow from the decreasing head. The basin is used as a large lock, by lowering its water level to the level of the water outside; and, as a rule, the dock is worked to the tide of the day, but at low neaps the basin is used wholly as a lock.

As the middle of the sills is lower than the bottom of the basin, a channel has been made along the basin, between the entrance and passage, 1 ft. deeper than the lowest part of the sills, so that vessels which can pass over the sills can enter the basin. The dock is 3,400 ft. in length, the maximum width being 1,100 ft., divided into two arms at the western end by a mole. The northern arm is 1,500 ft. long and 500 ft. wide, and the southern arm 1,200 ft. long and 300 ft. wide. The full width is left at the eastern end for a length of 1,000 ft., where the largest vessels can swing, even when all the berths at the tips and quays are occupied. The bottom of the dock—which is not puddled—is 20 ft. below mean sea level, and the quay roads are 26½ ft. above the same level. To the northeast of the main dock is the East Dock, now under construction.



THE LADY WINDSOR NEW DEEP LOCK, BARRY DOCKS, ENGLAND.

1895 has been a bad year for crops in Russia, the wheat crop for 1895 being 80,000,000 bushels smaller than in 1894 and the crop of rye being 115,000,000 bushels smaller.

HIGH OFFICE BUILDINGS IN NEW YORK.

Viewed from either the Hudson or East River, the lower portion of New York City presents a curious and not unpleasing appearance—the varied and picturesque sky line, when viewed at some little distance, suggesting the turreted wall of a mediæval city. This appearance is due entirely to a purely American product—the high office building. These lofty buildings are by no means confined to New York, but the conditions which prevail on the lower end of Manhattan Island afford more excuse for their existence than in a city like Philadelphia or Chicago. As the island begins to narrow rapidly, traffic becomes congested and business becomes more and more centralized until possibly the maximum is reached somewhere near Wall Street. The price of land in this section is simply enormous, and, as the old ground leases expired, individuals and corporations began the erection of taller and taller buildings, until now they are little more than towers.

The cast iron period gave way to the skeleton steel construction, and the limit of height made possible by it does not appear to have been reached yet. Elevator service improved until now we have elevators which can be run to the twentieth story at the highest rate of speed consistent with safety. The elevator was, at first, a mere convenience, but now it enables a real estate owner to multiply the area of his property almost indefinitely, at the expense, of course, of his neighbor's light and air. Gradually the buildings gave way to more pleasing designs, for the commercial value of the really artistic office building has been recognized by the owner, for the tenant, even though he be a layman, will usually select the more artistic building, all other things being equal.

The American Surety building, at Pine Street and Broadway, which we have already illustrated in detail, is a fine example of the latest office building. It was erected on a square plot of ground measuring about 85 ft. to the side. On this ground, which cost $1,500,000 (or at the rate of $8,000,000 an acre), was erected a building twenty-one stories high, at a cost of about $1,500,000; this building then represents an expenditure of $3,000,000, the twenty-one stories must be made to pay a dividend on the $3,000,000. This building was built by shrewd financiers, who evidently saw their way clear to make the building pay, and since it was finished other buildings, equally tall, have been begun.

An office building is a commercial enterprise, and it would seem that the height would be limited when the point was reached when the necessary construction decreased materially the interior areas, when the lower stories become so dark that offices are only rented with difficulty, and when the elevator service becomes too expensive or the trips too long for the tenants. There is one other factor which seems destined to limit the height of the office building, and that is legislation. Real estate owners appear divided as to whether or not the law should step in and decide the point. Chicago has passed a law limiting the height of buildings to 180 ft.; Boston, to 125 ft. In Paris the maximum height of the cornice is 65 ft. 8 in., not including the mansard. The result in Paris is to render the streets somewhat monotonous in appearance, but on the whole it is a very agreeable monotony.

At the 1896 exhibition of the Architectural League a large number of the designs shown were for high office buildings, which indicates a readiness on the part of the profession to make plans for any number of office buildings desired, but they do not appear to be unanimous in regard to their height, for one of the most eminent architects in the United States drew up the Pavey bill to regulate the height of buildings in the city of New York. This bill was introduced into the Legislature at Albany February 12, 1896. A part of the bill reads: "No building shall hereafter be erected in the city of New York in which any floor occupied or used . . . shall be of greater height above the curb level at the center of the front than fifteen times the square root of the width of the street, . . . and whenever any building shall front on the street, road or avenue over 100 ft. in width, its width shall be taken to be 100 ft. in making the calculation." With a few exceptions this would prevent the erection of buildings more than 150 ft. high in any part of the city, and to put a still lower limit of buildings in the narrow down town streets, as Nassau Street. Some of these streets are already little more than narrow cañons, which are rarely visited by sunlight and through which the wind rushes in gusts.

This bill undoubtedly voices the opinion of a large part of the community, for it would perhaps be more desirable for architects to build lower buildings, as the engineering problems connected with high buildings either require the architect to be an experienced engineer or to engage the services of one. The responsibility of the architect is very great, as the construction of every part of the building requires constant oversight, for only a few months ago a skeleton frame building collapsed, causing the loss of several lives and necessitating an entire reconstruction of the building from the footings up.

Views from the American Tract Society's building, 260 feet high, the Manhattan Life building, 242 feet high, or the American Surety Company's building are most interesting. Spread out before the spectator is the Bay, with the Narrows and Staten Island in the distance; nearer is the Statue of Liberty and that crowning relic of bygone days, Castle William; to the west are the Jersey Meadows, the horizon being bounded by the Orange Hills; then come the Palisades and the Hudson River, and finally the streets of the great city stretching away for miles, directly below the people look like ants, and the roar of the great

BIRD'S EYE VIEW OF THE BROOKLYN BRIDGE FROM A HIGH BUILDING IN NEW YORK.

city is softened into a subdued hum. To the east stretches away the Sound and Long Island, while the city of Brooklyn fills the middle ground.

Paris may have an Eiffel Tower, but for all ordinary purposes of observation the high office building answers as well and is vastly more convenient. Probably a better idea can be obtained of the true height of the office building by observing it from another high building than in any other way, for it is as true with architectural constructions as with mountains that their true height cannot be properly gaged by the eye by looking at them from the base.

Our engraving shows a bird's eye view of the city taken from one of its tallest buildings. The two driveways and the pathway for pedestrians, also the cable roads of the Brooklyn Bridge are clearly shown, as well as the roof of the railway station. The high building in the foreground is the Metropolitan Realty building. The East River and a portion of Brooklyn are shown in the distance.

INTERNATIONAL BICYCLE EXPOSITION AT PARIS.

WE illustrate herewith a few of the novelties exhibited at the recent International Bicycle Exposition at Paris.

In Fig. 1 is shown a new chain—the "Simpson," an English invention. As may be seen, the cheeks of the links, M, are in the form of open triangles, the lower angles of which are connected by pins whose extremities are flush with the surface of the cheeks, while the pin of the upper angle projects slightly on each side. The front sprocket of a bicycle provided with such a chain differs in nowise from ordinary sprockets, but the rear one, P, on the contrary, consists of two parallel notched disks forming a deep groove into which the chain passes and with which it engages solely through the projecting extremities of the pins, which enter the notches of the periphery.

The partisans of the suppression of the chain exhibited a dozen types of machines more or less new, and among which may be mentioned the Acatene-Cesar, the Cyclet and the Watteyclette.

The Acatene-Cesar (Fig. 2) is the best known model. The motion of the crank arm is transmitted to the driving wheel through the intermedium of a hollow shaft revolving upon the tube that forms the lower part of the frame to the right. This shaft is provided at each extremity with a bevel wheel that gears at one end with the front sprocket and at the other with the rear one. This mechanism is inclosed in small aluminum boxes filled with vaseline, so that neither dust nor water can enter, that perfect lubrication is assured and that the aspect of the machine is very peculiar and yet very elegant.

The Cyclet (Fig. 3) is more radical still as regards revolution. In it the chain, bevel wheels and all intermedia between the crank arm and the axle of the driving wheel are suppressed. It is upon the latter wheel that the cranks are mounted. These are provided with wheels toothed internally that actuate a small toothed wheel, n, mounted upon the hub of the driving wheel. The entire mechanism is protected from dirt and dust by a double sheet of celluloid. This arrangement obliges the rider to pedal in a position that is not yet in vogue. It has the advantage of reducing the length of the machine and of thus facilitating the storage of it.

The Watteyclette (Fig. 4) is actuated by the alternate pressure of each leg upon the extremity of two large levers placed on each side of the frame. These levers, in the center, support a small toothed wheel which revolves around another mounted upon the axis of the driving wheel. It will be seen that the travel of the pedal is here shorter than in the circular motion of the pedal of an ordinary bicycle, and that, nevertheless, the force obtained is theoretically greater, since the pressure on the pedal is exerted for an equal length of time and with a much longer lever.

The recent exposition showed us that brakes are gradually being done away with. Is this wrong or right? From an æsthetical view point it is right, for the brake disfigures the looks of a bicycle, but from the view point of the rider's safety, as skillful as he may be, it is most certainly wrong, as every day, with its accidents, abundantly proves. So manufacturers have endeavored to ally the utile dulci, and have presented us with brakes as invisible as possible. In addition to the scientific brake of Jumel may be mentioned that of Rochet, which seems to be the best type of the lever brakes that act upon the steering wheel.

This brake (Fig. 5) absolutely frees the front of the machine. We see only the extreme end of the lever, which forms a handle concealed under the handle bar, and the brake block, which presses against the steering wheel. As regards the rest, it is invisible. Its rod, a, passes through the interior of the steering head, in which is likewise concealed the spring of the brake. It is conical at its extremity, b, and, through a simple regulating screw, c, is made to rise to the desired height in the tube, d, that carries the brake block. There is a tendency, too, to make the bicycle of smaller size, and also to fold it. Alongside of Captain Gerard's bicycle was exhibited that of Mr. Henault, called the "Vapartout," and which Fig. 6 represents folded and deprived of its saddle and wheels. The frame is of the usual form. The upper and lower tubes, as well as the steering post, are jointed at m, n, o and p.

The bicycle accessories have themselves become capable of being taken apart. After the extensible pocket lantern, we have the Desponts and Godefrey foot pump (Fig. 7), which is made in four pieces that enter one another, and which may be easily attached to one of the tubes of the machine. This invention, though apparently trivial, is of great importance to cyclists. No hand pump, in fact, is sufficient to inflate the present pneumatic tires, the valves of which are generally very hard. A foot pump is indispensable. But up to the present the pumps of this kind have been heavy and cumbersome. It is, therefore, a pleasure to make known this new device, which will render a service to all tourists.

One of the novelties of the recent exposition was a closed tricycle (Fig. 8) constructed by the Humber establishment. This machine, which is entered through a door in the rear kept closed by strong springs, is an ordinary tricycle surmounted by a frame made of aluminum tubes covered with an impermeable fabric. The complete apparatus weighs but thirty-seven pounds. It is a vehicle with pedals designed solely for running in crowded streets.

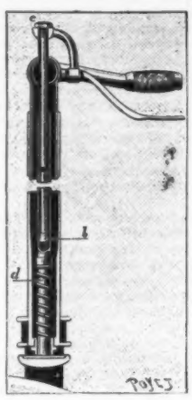


FIG. 5.—ROCHET BRAKE.

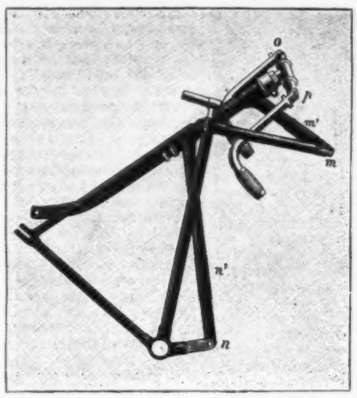


FIG. 6.—HENAULT FOLDING BICYCLE.

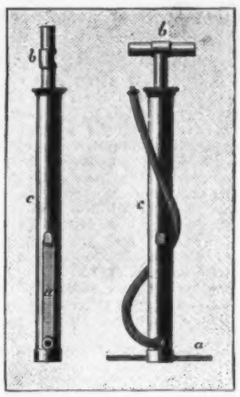


FIG. 7.—DESPONTS & GODEFROY PUMP.

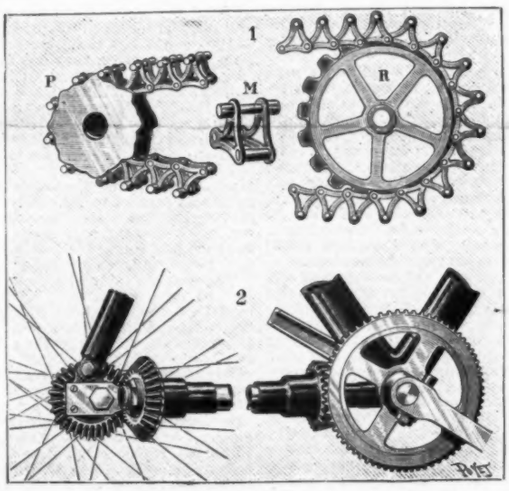


FIG. 1.—THE SIMPSON CHAINS—P and R, sprockets; M, link.
FIG. 2.—ACATENE-CESAR CHAINLESS GEAR.

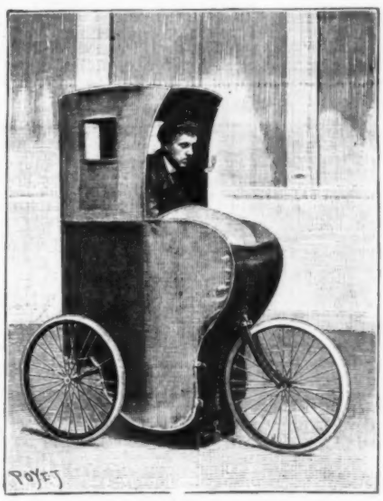


FIG. 8.—THE HUMBER CLOSED TRIPLET.

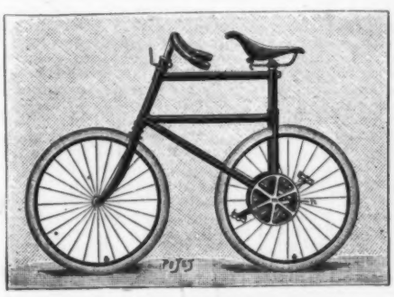


FIG. 3.—THE CYCLET.

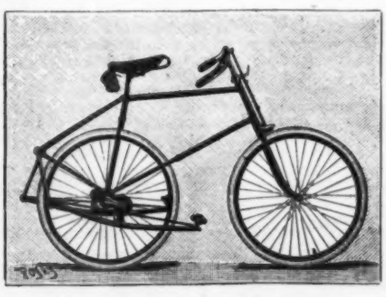


FIG. 4.—THE WATTCYCLETTE.

For the accompanying illustrations and details we are indebted to *La Nature*.

CHILLING TEST PIECES WITH LIQUID CARBONIC ACID.

WRITING on the use of liquid carbonic acid gas for chilling test pieces, especially stone, iron, and steel, at low temperature, M. Ph. v. Halier, in the Industrial Zeitung of Riga, says that a cheap and simple form of apparatus in which the test specimens could be cooled would consist of a wooden box with double walls, top and bottom, the spaces between being filled with some non-conducting substance. The liquid gas could be led into such a box from the iron and steel flasks in which it is furnished, and would be deposited in great part in the form of frost at a temperature of about 78° Centigrade. The test specimens could be readily put into and taken from such a box, and would quickly get a low temperature. One of the Russian railroad companies is on the point of having such an apparatus constructed for testing rails and wheel tires at low temperature. The possibility of accomplishing the desired object with such an outfit, viz., the rapid freezing of specimens, was demonstrated by putting a number of iron test pieces into a bag of several thicknesses of coarse cloth and then introducing the liquid gas. This at once became solid and filled all the spaces between the specimens which thus lay packed in snow. Each specimen was provided with a depression, into which mercury could be poured, and in doing this, after a short exposure in the freezing bag, it was found that the mercury immediately solidified, showing, in the absence of a suitable thermometer, that the temperature of the specimens was certainly below 39° Centigrade if not lower. At the St. Petersburg Laboratory of Experimental Medicine a cold room of

quite large proportions has been fitted up, in which also liquid carbonic acid is the cooling agent.—Railway Review.

MECHANICAL ROAD CARRIAGES.

By W. WORBY BEAUMONT, M.Inst.C.E.

[Cantor Lectures before the Society of Arts.*]

LECTURE I.

WITH the exception of land and ruins there are few things of any material value to man which do not derive that value, in part at least, from transport from their original position. Hence means of transport are the greatest aids to riches and civilization, and men seem always to have been agreed on this, although they have disagreed as to the means. Even if we go no further back than the beginning of the nineteenth century we find a committee of our own House of Commons reporting very strongly on this subject in 1808. They did not say that roads and conveyances were of more importance to us than the sun, but they were very near this in opinion. They said "next to the general influence of the seasons upon which the regular supply of our wants and a great proportion of our comforts so much depend, there is, perhaps, no circumstance more interesting to men in a civilized state than the perfection of the means of interior communication."

There was no reason then, nor is there now, for dissenting from this as a general proposition, but there were in the earlier days of its realization reasons why it should receive assent in theory but opposition in practice. When carriages became common in this country an act was passed to prevent their too general adoption lest the horses should consume the food of the poor.† This was no doubt a sufficient reason at the time for such an act, as supplies were not then easily distributed and not much obtained from abroad, but we have the satisfaction of knowing that, cogent as it may have been then, it has no basis in fact now, for the food of the poor is no longer the food of horses, and it is certainly of very little direct use to the internal combustion engine or the electric motor.

This question of ways and means, however, was one which introduced in the days of only horse traction one of the greatest obstacles to increased means of transport. The food of the motor was the food of man, and as one horse was alleged to consume as much food as eight men, the limit to the number of horses that could be kept upon the work of a given population engaged chiefly in agriculture was soon reached. From the very first, therefore, any means of locomotion which promised to make horse traction unnecessary acquired great importance, as is shown by the interest which statesmen and economists took in them. Few things in connection with the subject of internal communication by roads are more remarkable than the impartial and broadminded consideration which was given to it by the select committee of the House of Commons which was appointed in 1831 "to inquire into and report upon the tolls and prospects of land carriage by means of wheeled vehicles propelled by steam or gas on common roads." It was remarkable because, with the exception of some of the leading statesmen, the designers of early road carriages and a very small following, the greater part of the population and nearly all those interested in the then means of road communication were actively opposed to mechanical carriages of any kind. To an engineer looking over the history of the early nineteenth century steam carriage enterprise, few things are more striking than the efficacy of the opposition of mere stolid indifference to the requirements of the many, or the unreasoning objection to novelty. When we look at the splendid treatment of the subject and broadminded views expressed by Tredgold in his treatise on railroads and carriages, published in 1825, it is astounding to find how much there is which, in its practical infancy to-day, was clearly foreseen, and, to a great extent, described seventy years ago by this remarkable man. Even the possibility of the use of the gas engine for traction purposes was entertained by him. Although this was not realized until within the past few years, it was not because the gas engine was an impossibility, but because of the then far greater perfection of the steam engine. Tredgold's remarks on the subject were not a mere guess or lightly thrown off imagining of the dreamer, nor was it born of mere enthusiastic hope.

We have enabled or allowed steam to "drive the rapid car," but the road carriage which approached practical completeness in 1835 is not allowed even yet to perform the good services which we now know it might. For sixty years has this powerful aid to locomotion lain dormant. It is impossible to conclude that this neglect can be due, or has been due, entirely to short-sighted opposition on the part of those who conceived their interests to be assailed; and a consideration of the efforts of sixty years ago makes us ask whether the reasons upon which the present revival of interest in road carriage development is based are much better founded than they were then. To this point I shall return hereafter, but I may here remark that, however much we may regret the disappointments of the hopes of those who sixty years ago labored hard to prove the possibility of intercommunication by mechanical carriages on common roads, the intervening lapse of time has not been loss of time. It is a reflection which is often forced upon us that it is questionable whether in the nature of things it is even desirable that farreaching inventions should take their full effect rapidly.

The history of road locomotion and of railway locomotion, like the history of other fields of invention, has shown that in the development of the most wanted the development of a thing only less wanted is stopped. These were the relative positions of the railway or railroad, as it was then called, and the steam carriage in the early part of this century.

There can be no doubt that much as improved transport on the high roads and subsidiary roads was required all over the country early in this century, that which the builders of railways offered and provided was most required. They not only gave the means of somewhat more rapid transport between the great centers of the country, but they offered what is of the greatest value in all things having a commercial basis for their importance, namely, a definite, comprehensible and attractive business application for large quantities of capital. There was not the same footing for the steam carriage, for it did not propose to draw capitalists together in the purchase of lands and in the establishment of a great monopoly which could perform what could not be performed without it, as the railroads did. The steam carriage only proposed to do rather more quickly and at somewhat lower cost precisely what was done by horses. It proposed to use the public roads and was subject to restrictions and tolls which did not affect horse-hauled carriages, and these tolls were in some cases raised by the turnpike trusts to nearly as many pounds as they could charge shillings for horse-hauled vehicles. It mattered not that it was proved that the horses' shoes cut up the roads much more than the wheels of the coaches.* The opposition had its reasons or prejudices which were sufficient to crush a new enterprise with no statutory powers.

Whether the makers of steam coaches were prepared to do a carrying trade on any scale is a matter which can be best seen by reference to the history of these things, and to this I may now turn, although the history is more of ingenious effort than of success. There is ample reason for dwelling on these failures, for a knowledge of them shortens the road to success, as Sir Humphry Davy remarked, but it needs wisdom and discrimination to determine where, why and to what extent the failure was not a success, and that judgment which is derived from practical experience as well as knowledge, to tell when a failure is due to system or to detail.

The mere conception of a carriage mechanically driven somehow by steam was shared by a good many whose names and proposals need not be dwelt upon here. Bacon speculated upon the possible use of fire and steam engines, and drawing carts without horses was the subject of part of a patent taken out in England, in 1619, by two men named Ramsay and Wildgosse, and the latter was very nearly the name of the chase they both embarked upon. Even Sir Isaac Newton is credited with the invention of a steam carriage, which was merely a kettle on a carriage, the spout of which was turned rearward, and, being provided with a horizontal jet piece, formed a single jet reaction apparatus, similar to many of the steam toys with which our children are now provided for a few pence. It was a Hero's steam engine, with but one jet, and was inferior to Giovanni Banca's steam turbine of 1629.

Dr. Robison was impressed with the possibility of the application of steam to carriage propulsion, and discussed the matter with James Watt, but the latter discouraged him, as he did Small and Moore with respect to their proposals, and as he did William Murdock, who had made a really successful locomotive.† In 1790 Nathan Read took out a patent for a steam carriage, in which the pistons of two cylinders were connected to racks which moved pinions on the driving axles, ratchets being used to give motion only one way. This rack and ratchet motion was subsequently used by several others, who made steam carriages or models of them. Read turned his exhaust jets rearward, to act as additional propellers after the manner of Newton's jet. As the pressure of his exhaust was probably nearly boiler pressure at the instant of release, each jet would have been as good as Newton's. Read's boiler, like those of many who followed him, bore no relation to the capacity of the cylinders, unless it was that of equality in steam space dimensions.

The first inventor of a steam road locomotive or carriage who really achieved any success was Nicholas Joseph Cugnot, who built one in 1769, and a better one in 1770.‡ Cugnot was an officer in the French army, and made his carriage with a view to carrying artillery. It was, or is—for it may still be seen in good preservation in the Conservatoire des Arts et Métiers, Paris—a three-wheeled vehicle, the front or single wheel carrying the weight of the engine and boiler, being 4 ft. 2 in. diameter. The cylinders are vertical, 13 inches diameter, and the piston rods are connected by ratchets and radius arms to two small ratchet wheels on either side of the front wheel. The steering was effected by moving the whole of the propelling machinery and boiler on a pivot. The latter was, as with all early inventions, too small. It was of copper, and its position made the whole carriage unsteady. Indeed, this was the cause of its being capsized and disused after a brief history of out-of-breath running for a short distance at about three miles per hour.

From the time of Cugnot, inventions too numerous to be mentioned were made, almost all of which were by amateurs whose enthusiasm was in proportion to the incompleteness of their mechanical knowledge or experience. We may pass them all until we come to that of Murdock, of 1781–84. This was a steam locomotive, made only of small model dimensions, but, as a model, it worked satisfactorily, and was remarkable for its simplicity and directness of the application of the power of the motor.§ There were in it some points that were essential to success, points which were missed by subsequent inventors, but they were not easy of interpretation from the model to the large scale.

He had the direct connection of the long stroke piston to a crank with wheels, which depended merely on adhesion for their tractive sufficiency. He used no gear. Some things which he did not require in a model were necessary in a large size road carriage, but the translation from a model to the larger size, and doubt as to the sufficiency of mere adhesion, put subsequent inventors on a wrong track.

Murdock made one model with a cylinder of ¾ inch diameter and 1½ inch stroke, and of this model carriage Boulton and Watt's agent in Cornwall, Thomas Wilson, wrote to Soho that "it answers amazingly."

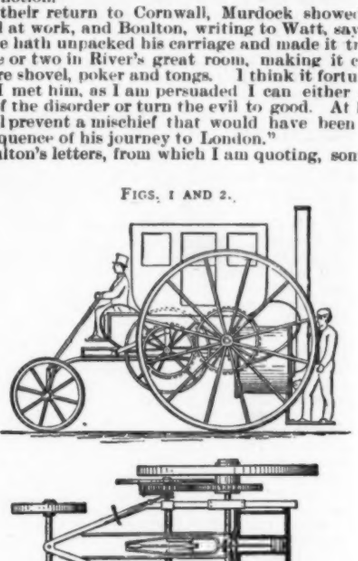
This is probably the model presented to the Birmingham Art Gallery by Messrs. Tangye, a copy of which is now in the South Kensington Museum. There is evidence that Murdock made two, if not three, model engines, and it is now known that Boulton & Watt, for their own business reasons, prevented Murdock, who was then their servant, from patenting his engine, or taking any steps to bring it into use. In September, 1786, Boulton, on his way into Cornwall, met Murdock at Gloucester on his way to London with that object, but Boulton succeeded in persuading Murdock to return to Cornwall, and not waste his time and money in pursuing the steam carriage notion.

On their return to Cornwall, Murdock showed his model at work, and Boulton, writing to Watt, says:

"He hath unpacked his carriage and made it travel a mile or two in River's great room, making it carry the fire shovel, poker and tongs. I think it fortunate that I met him, as I am persuaded I can either cure him of the disorder or turn the evil to good. At least I shall prevent a mischief that would have been the consequence of his journey to London."

Boulton's letters, from which I am quoting, some of

FIGS. 1 AND 2.



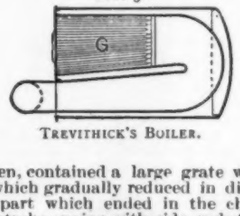
TREVITHICK'S STEAM CARRIAGE.

which have never yet been published, show that he and his partner highly valued Murdock's services, and as they could not themselves take up the steam carriage or locomotive, they did not scruple to dissuade him from what they thought would be less to their advantage than to Murdock's.

In 1786 W. Symington, who made the first practical steamboat ever built, patented a road carriage. A cylindrical boiler with a lever safety valve was used in the model of the carriage, and this supplied steam to the cylinder of an atmospheric condensing engine, the piston rod of which communicated motion by means of rack and ratchet wheel. His arrangement of coach and engine was better than that of some of his followers, but it does not seem to have been carried out, and the rack and ratchet which would have been a fatally defective detail.

The next inventor who made any appreciable strides toward practical success was Richard Trevithick, a model of one of whose locomotives may be seen in South Kensington Museum. The genius of Trevithick was shown in the remarkable simplicity of the engines he designed and in the proofs that they afford of his sense of mechanical fitness. He was a man of practical experience in connection with pumping engines and mining machinery, and the effects of this experience are shown in his designs both of his locomotive,* and in the design of the steam carriage, Figs. 1 and 2. In his locomotive for railroads he used a boiler of considerable size, which is shown in horizontal section in Fig. 3. It was cylindrical in form, and

FIG. 3.



TREVITHICK'S BOILER.

as will be seen, contained a large grate within a furnace tube, which gradually reduced in dimensions in the return part which ended in the chimney. He used a long stroke engine with side rods from a crosshead coupled direct to crank pins in the driving wheels.

The steam pressure was 60 lb. and the exhaust steam was turned into the chimney to create a draught. Steam was admitted and emitted by means of a four-way cock by tappets connected with the crosshead, and the boiler was provided with a safety valve and with a fusible plug. As first made the locomotive was provided with the bellows, but this was not used after the first run. Large as Trevithick's boiler was when compared with that of previous inventors, it was nevertheless insufficient in heating surface—a fault which Trevithick avoided in his third attempt, which was the construction of the steam carriage, shown in Figs. 1 and 2, under a patent granted to him and his friend Vivian in 1802. In this case Trevithick departed from his previous simplicity of design in that he used gearing to connect his crankshaft with his driving wheels, but as in his first small locomotive he used a flywheel; but in this case it was placed upon the crankshaft instead of being driven by gear at higher speed than the crankshaft. The carriage shown in Figs. 1 and 2, seems to have been so far a

* From the Journal of the Society of Arts.

† This is stated by Gordon in his "Elemental Locomotion," but I have not verified it.

* On this subject a great deal of valuable information was given by Farey, McNeill, Telford and McAdam in evidence before the select committee of 1831, not only on this question, but on the widths of tires generally used, the weights of wagons and the numbers of horses used. See "Historical and Practical Treatise upon Elemental Locomotion," by Alexander Gordon, C.E., London, 1832.

† See the Engineer, June 10, 1881, p. 432.

‡ See "Proceedings Institute Mechanical Engineers," 1853, paper by E. A. Cowper, p. 33.

§ See "Steam on Common Roads," by W. Fletcher. London: E. & F. N. Spon, 1891.

* Trevithick's first models were made in 1796–1798, and his road carriage in 1802. See Fletcher's "Steam on Common Roads."

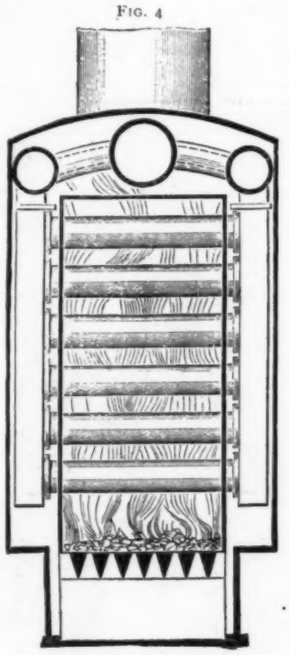
practical success that it ran a considerable number of journeys at a speed reaching as much as ten miles per hour, but on one occasion, owing to the faulty steering of Trevithick's partner, the carriage ran too close to the side of the road and tore down several yards of palings, an incident which caused considerable expense, and the withdrawal of the coach from the road.

After three years spent on these trials, which emptied the pockets of Trevithick and Vivian, the engine was taken from the coach and sold for driving a hoop rolling mill, which it did for many years. It will be noticed that the gearing in this carriage permitted the engine to run at a higher speed than the road wheels, which were of great height, and either of the cog wheels on the crankshaft could be thrown out of gear, so as to leave the road wheels free for turning corners. There is ample evidence that the carriage shown in Figs. 1 and 2 was exhibited at work in and about London for a considerable time, but it failed for reasons which are not at all obvious now; but it is more than probable that it was an inconvenient, noisy and uncomfortable substitute for the horse-hauled coaches of the time, and these objections, no doubt, lent considerable aid to those who opposed such coaches on other grounds.

From the time of Trevithick nearly a quarter of a century passed, during which very little of note was done toward the construction of a practicable steam carriage, although the names of seven or eight inventors are associated with patents, and with experimental attempts to do, in an inferior way, what Trevithick had already accomplished. Several of these, believing that the adhesion of ordinary wheels was insufficient for tractive purposes, designed a variety of ingenious arrangements for propulsion by means of legs and feet, supposed to imitate the action of horses. One of these was by David Gordon, and was patented in 1824. It is unnecessary, however, to occupy any time in describing a failure, which no one in these days would be in the least likely to repeat.

In 1821 Julius Griffiths patented a steam carriage. It was constructed by Bramah, and the engine and its parts, it need hardly be said, were well made. The coach was carried on a long under frame between four road wheels, and the boiler was supported by an ingenious kind of spring suspension from framework at the rear. It is mentioned as the first steam coach constructed in this country with anything like comfortable accommodation for passengers. The engines consisted of two vertical cylinders connected to a crankshaft, which, by gearing, drove the hind wheels at one or other of two different speeds. The boiler consisted of a series of horizontal water tubes 1½ in. in diameter and 2 ft. in length, their ends being connected by flanges to flat, vertical water chambers, as shown in Fig. 4. The water chambers were connected

FIG. 4

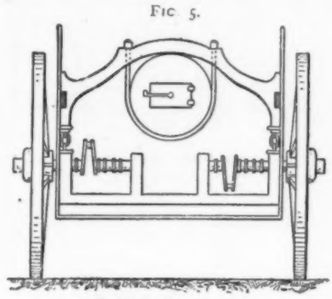


GRIFFITHS' BOILER.

across the top by transverse and longitudinal tubes which formed the steam receivers and to some extent superheaters. There were 114 of the cross tubes, the heating surface of which would be about 89 ft., and this with the surface of the chambers would bring the total heating surface up to from 110 to 120 square ft. It is not, however, clear from the published accounts whether the ends of the tubes, and therefore the side water chambers, were allowed to act as heating surfaces, or whether they were embedded in the non-conducting material to the black lines shown in the diagram, and in this case the heating surface would be less than that given for the tubes alone. In the drawings of his patent specification (No. 4,630) of 1821, the boiler is shown as consisting of cross tubes connected together at the ends by short bends and not by the chambers. Griffiths' steam carriage failed because of the failure of this boiler, and as described by Alexander Gordon, the boiler could not be prevented from priming and the tubes near the fire were intermittently supplied with water and emptied by the generation of steam within them. The result was that the pumps failed to keep the boiler supplied with water and all endeavors to keep it tight at its numerous joints failed. Griffiths used an air surface condenser, which is described as having consisted of a number of thin, flat tubes, exposed to the cooling influence of the air. Contemporary accounts speak of the success of Griffiths' carriage in everything except the boiler, but as this failure never allowed the carriage to go beyond Messrs. Bramah's yard, it is not known now whether this condenser was tested or not.

In 1825, a patent (No. 5,090) was granted to Messrs. Burstall & Hill for a steam carriage. A grasshopper engine was used and the boiler was carried at the rear. The beams of the two cylinders were directly connected to cranks at right angles, the main axle being the crankshaft. It was intended to make the front axle also a driving axle by means of the bevel gearing, there being a universal joint just in front of the water tank to permit of the movement of the front wheels for steering. The boiler seems to have been again in this case, as in others, the chief cause of failure. It consisted of a cast iron fire box, the upper surface of which formed shallow dishes immediately over the fire grate. Into or on to these trays water was injected from the feed water tank, which was made to sustain a pressure of about 60 lb. a square inch. This pressure was maintained by pumps which forced air into the upper part. The boiler was in fact of the type commonly now known as instantaneous generators, the shell being of wrought iron surrounding the cast fire box.* The inventors proposed to maintain their flat, vaporizing trays or surface at a temperature of from 250 to 600° F. or more, and only allow the injection of the water from the pressure tank to take place when steam was

FIG 5.

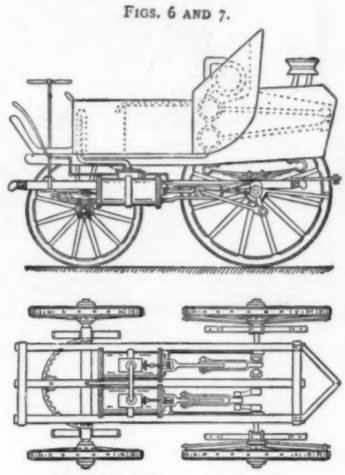


JAMES'S CARRIAGE.

wanted. Thus it was thought they would store heat in this heavy cast iron fire box top and sides when going down hill or during stops when steam was not being generated. They seemed to think iron better than water for heat conservancy. A good deal of money was spent on this carriage, but all the experiments resulted in failure, partly because of the insufficient power of the boiler, and partly because of the great weight of the carriage and its heavy machinery. The engines were said to be capable of giving off 10 horse power. The steam was supplied to them through the coiled steam pipe shown, the flexibility of which permitted of the slight movements of the boiler, which was suspended by springs. Similar coiled pipe connection was also used between the pressure tank and the boiler. It is also interesting to note that the exhaust from the engines was passed into what we would now call a silencing box, and its emission therefrom regulated. After the failure of this carriage the authors modified their design considerably, simplifying the engines, and driving the main hind wheels, by means of cranks outside them, and connecting rods working from the cross heads of vertical cylinders. They also used a coffee pot form of boiler, carried in a frame supported partly by the hind axle of the coach, and partly by a third axle, carried by two hind wheels, thus making a six wheel coach. This arrangement was, however, never carried into practice, except on the small scale of a working model. Timothy Burstall was a very ingenious man, with a good deal of inventive ability, and he made several improvements, for which he took out patents. One of these was for a tubulous boiler, and another for a locomotive driven by steam reaction wheels; another was for hydraulic propulsion.

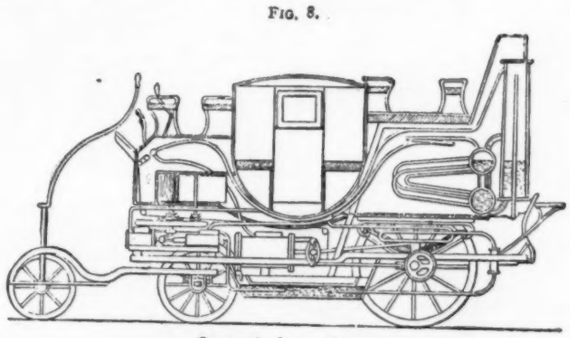
In the same year the subject was taken up by W. H. James, who, in May, 1824, took out a patent for an improved method of constructing steam carriages, in which he disclosed several features of novelty, and of considerable interest, even at this time. He departed entirely from the previous methods of connecting his engines to the road wheels, and he used two tubular boilers, which, in capacity, were better proportioned to the size of the engines. He used four cylinders, 3¼ inches in diameter, and with long stroke, coupled to two crank shafts, as shown in Fig. 5, each pair of cylinders and driving wheel being independent, and thus making it unnecessary to use any compensating gear for turning corners. James used a steam regulator, which was operated by the steering gear, so that more steam or less steam was given to either set of engines, to suit the different number of revolutions they would have to make in traversing either the smaller or greater curves in turning. James' boiler consisted of a number of rings of tubes, connected together, and placed one outside the other, thus forming a series of annular spaces, alternately, of tubes about three-fourths filled with water and of heated gases, the fire being in the central ring of tubes, which was 1 ft. 9 in. in diameter and 4 ft. 6 in. in length. A considerable measure of success was achieved with this carriage, but the material of which the boiler tubes (namely, gas tubes 1 inch in diameter) was made was unsatisfactory, and gave considerable trouble by splitting. The carriage itself, moreover, was heavy, and, from repeated alterations, apparently useless. It was, however, sufficient to prove the practicability of such a coach, and it is stated that a journey from Epping Forest into London was made with only one boiler in operation, the coach and its machinery weighing about 4¼ tons. In 1829 James constructed another carriage, embodying, so far as the boilers were concerned, the results of the previous trials, but intended more as a traction vehicle than as a carriage. He used, in this case, four boilers of the kind mentioned, made up of nearly 200 tubular rings, measuring in all 400 ft. in length of ¾ in. tube, inclosed in a space 4 ft. wide, 3 ft. long, and 2 ft. deep. The steam from each boiler was conducted to a trunk tube above, and from thence to the engines, stopcocks being placed so as to shut off either boiler from the trunk tube. The cylinders for this second carriage were 2¼ inches internal diameter and of 9 in. stroke, and they were placed vertically and carried by trunnions. The steam pressure employed was about 200 lb. per square inch, and the exhaust was at such a high temperature that it melted the solder of two copper tanks, in which it heated the feed water, and made it necessary to hard solder them. From these feed water tanks the steam passed to the chimney. Although this carriage was completed, after having acquired the valuable experience of the previous effort, James did not achieve with it the success that the first experiment justified those concerned to expect. It will have been observed from the brief description I have given that he departed radically from the arrangement and design of the engines he first used. James thus made the mistake, which has been made by many inventors since, of throwing away valuable experimental teaching for the sake of new experimental inquiry. He mistook failure in detail for failure in principle, and instead of pursuing that which had achieved a considerable measure of success, he started on a new track, in which he could be but little guided by even the most judicious interpretation of his previous failures.

FIGS. 6 AND 7.



GURNEY'S TRACTION CARRIAGE.

FIG. 8.



GURNEY'S STEAM COACH.

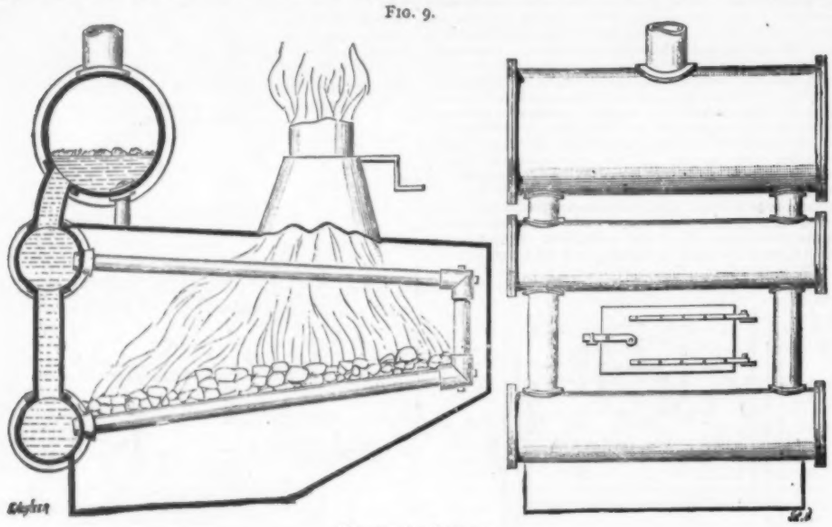
Goldsworthy Gurney* was the next to make any important advance, and although he commenced with a steam carriage, impelled by legs moved backward and forward by steam cylinders, he subsequently discarded these, and, under patents taken out in 1825, he made several coaches, with some of which he established a regular public conveyance between Gloucester and Cheltenham in 1831. The water tube boiler devised

* Hebert's "Engineer's Encyclopedia," 1835: also "Patent Specification," No. 5,186, of 1825. The boiler, according to this, had only one series of closely connected rings of tube forming a large furnace tube. See also "History and Progress of the Steam Engine," by Elijah Galloway. London, 1830, p. 391.

* Gordon, "Elemental Locomotion." Galloway, "History of Steam Engine." Hebert's "Engineer's Cyclopedia." Sir Frederick Bramwell's "Reminiscences of Steam Locomotion on Common Roads," Brit. Assoc., 1894.

by Gurney was an essential feature in Gurney's invention, and although there were other good points in his carriage, there is no doubt that he owed his success very largely to this boiler. Figs. 6 and 7 show one of Gurney's carriages intended chiefly as a traction vehicle or locomotive. Fig. 8 shows Gurney's coach in section. This view is sufficient to show the general arrangement of the engine, boiler, connections, and coach. The boiler is shown by Fig. 9, which depicts it in the form it took after several had been made. It is seen in the first form in Fig. 6, which was one of the last vehicles Gurney made. It consisted of a layer of

FIG. 9.



GURNEY'S BOILER.

nearly horizontal tubes, which formed a large grate, and these were connected at one end to a horizontal cast iron trunk tube, which was immediately below a similar horizontal trunk tube, to which it was connected by two vertical tubes, as seen in the large view, Fig. 8. Above the fire was a series of straight tubes, similar to those forming the grate, and connected to them and to the upper trunk tube. Above the upper trunk was a receiver, partly filled with water, and from this the steam was taken off to the engines. In the boiler used in the coach, which is shown by Fig. 8, the receiver or steam chamber shown in Fig. 9 was not used. Instead of it the upper of the two trunk tubes shown in Fig. 9 acted in part as steam chamber, and from it the steam passed into two vertical wrought iron receivers at the back of the coach. These receivers acted as separators and the water in the bottom of them was in communication with that in the lower trunk tube. In the coach short curved pipes led the steam into these separators and from the top of the latter a pipe passing down through the chimney over the top of the space containing hot gases, under the carriage body, conveyed steam to a point immediately under the driver's seat where there was a stopcock under his control and from which a short length of pipe took steam to the engine cylinders below. The feed pump carried by the rear framing took water from tank seen below the cylinders and forced it through a pipe which was carried into the upper space in the combustion chamber, where it was bent into a coil before entering the steam space of the upper horizontal trunk tube. The pipe was convoluted beneath the boiler so as to give elastic flexibility to prevent breakage by vibration. It will be noted that the feed water was heated, and that it entered the boiler in the steam space and not the water space. In the front of the coach and under the driver's seat and box is shown a horizontal fan engine. This was used for supplying air to the furnace, but in the last of his carriages, Gurney turned the exhaust steam into the chimney and in this way obtained all the blast required, the exhaust issuing from several jets which were under control. The carriage which is shown by Figs. 6 and 7 was apparently successful as what might be called a light road locomotive, but it appears to have been made only a short time before the opposition and prohibitory tolls made it necessary to take the coaches off the road. The steering in them was effected by means of a semicircular rack attached to the front axle, and into which a pinion on a vertical shaft geared, the top of the vertical shaft carrying a four-way handle. It will be noted that this vehicle was a simple, practicable machine, worked by engines having cylinders of a small diameter and long stroke and supplied by ample boiler capacity. The objections which obtained with the hot boiler, steam vessels, and pipes, when forming part of the passenger coach itself, were removed by using this separate steam vehicle, which he called a drag.

(To be continued.)

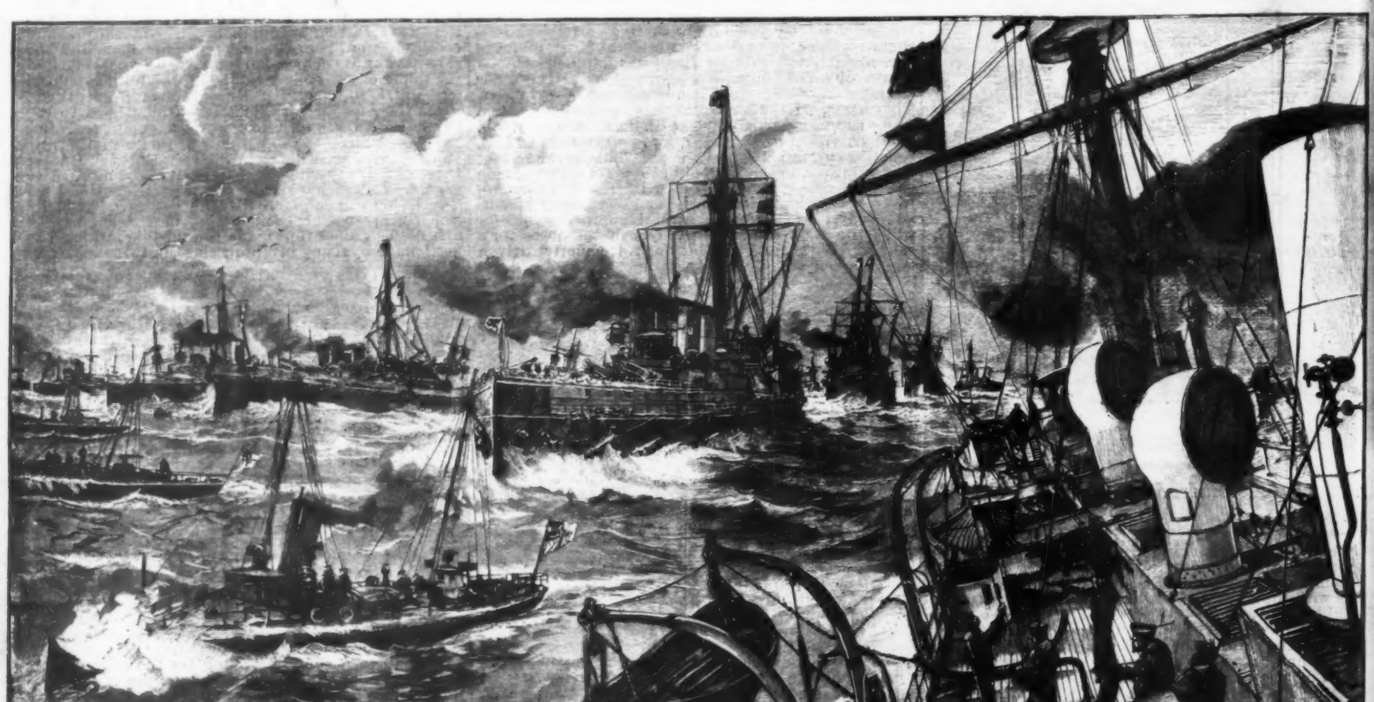
THE GERMAN NAVY.

IT would seem as though the splendid success of the German army in the war of 1870, and the efforts which have subsequently been directed toward its further development under the consolidated empire had absorbed all the interest and resources of the German people, and had prevented any attempt to build up a navy that should be truly representative of the country. It was only with the accession of the present Emperor to the throne that an active naval policy was initiated; and it is largely due to his persistent efforts that the German navy possesses the modern and very fine vessels of the Brandenburg and Odin V class.

Of armored ships of all kinds there are thirty-four in the German navy. This includes ships built as long ago as 1868 and 1874 and gunboats of 1,100 tons displacement. Twenty of these armored ships were built previous to 1880, and fourteen since that date. Taking them in the order of their efficiency, we have first the Brandenburg class, of which there are four ships built and one proposed.

These are first-class battle ships of the barbette type. Their leading features are as follows: Tonnage, 9,842; dimensions, 345 ft. 4 in. by 64 ft., and 24 ft. 7 in. draught; speed, 16½ knots; belt armor, 11¾ to 15¾ in.; barbette armor, 11¾ in.; armament, six 11 in. guns in three separate barbettes, protected by overhead shields; six 3·4 in. quick fire guns on the broadside; and sixteen smaller quick fire guns. They are provided with seven torpedo dischargers. It will be seen that they are very powerful in the main battery, carrying six heavy guns, as against the customary four guns of the American and English battle ships. In this respect they resemble the Russian ships of the Sinope class, which carry six 12 inch guns in a central redoubt; but like them the Brandenburg class are weak in the secondary battery, carrying only six quick fire guns of the light caliber of 3·4 inches as against the eight 8 in. guns and four 6 in. guns of the Indiana, or the twelve 6 in. and sixteen 3 in. guns of the Magnificent. The three barbettes are placed on the center line, and consequently in dead ahead or dead aft fire the Brandenburg would only be able to bring the same number of heavy guns to bear as the Indiana or Magnificent; the fire of the midship barbette being limited to between 70 and 80 degrees on the broadside. The total foot ton energy of the 11 in. gun is 21,750 tons, and the perforation of iron at the muzzle 30·7 in. The Indiana's 13 in. gun has a muzzle energy of 33,627 foot tons with a perforation of 34·6 in. The figures for the 12 in. wire wound gun of the Magnificent are: energy at muzzle 30,940 tons, and perforation 38·5 in.

The armor belt is continuous from stem to stern, as in the French and Russian ships. The forward barbette is mounted on a high forecastle deck, and its



THE GERMAN FLEET.

guns are carried some 8 or 10 ft. higher than those in the central and aft barbettes. This increased freeboard will render these ships very seaworthy, particularly when steaming head to sea; and they could fight their forward guns when the same guns on ships with a lower freeboard would be completely drowned out.

The five ships of this class will be almost identical in size, equipment and speed; and in this respect they will be admirably adapted for maneuvering together in line of battle.

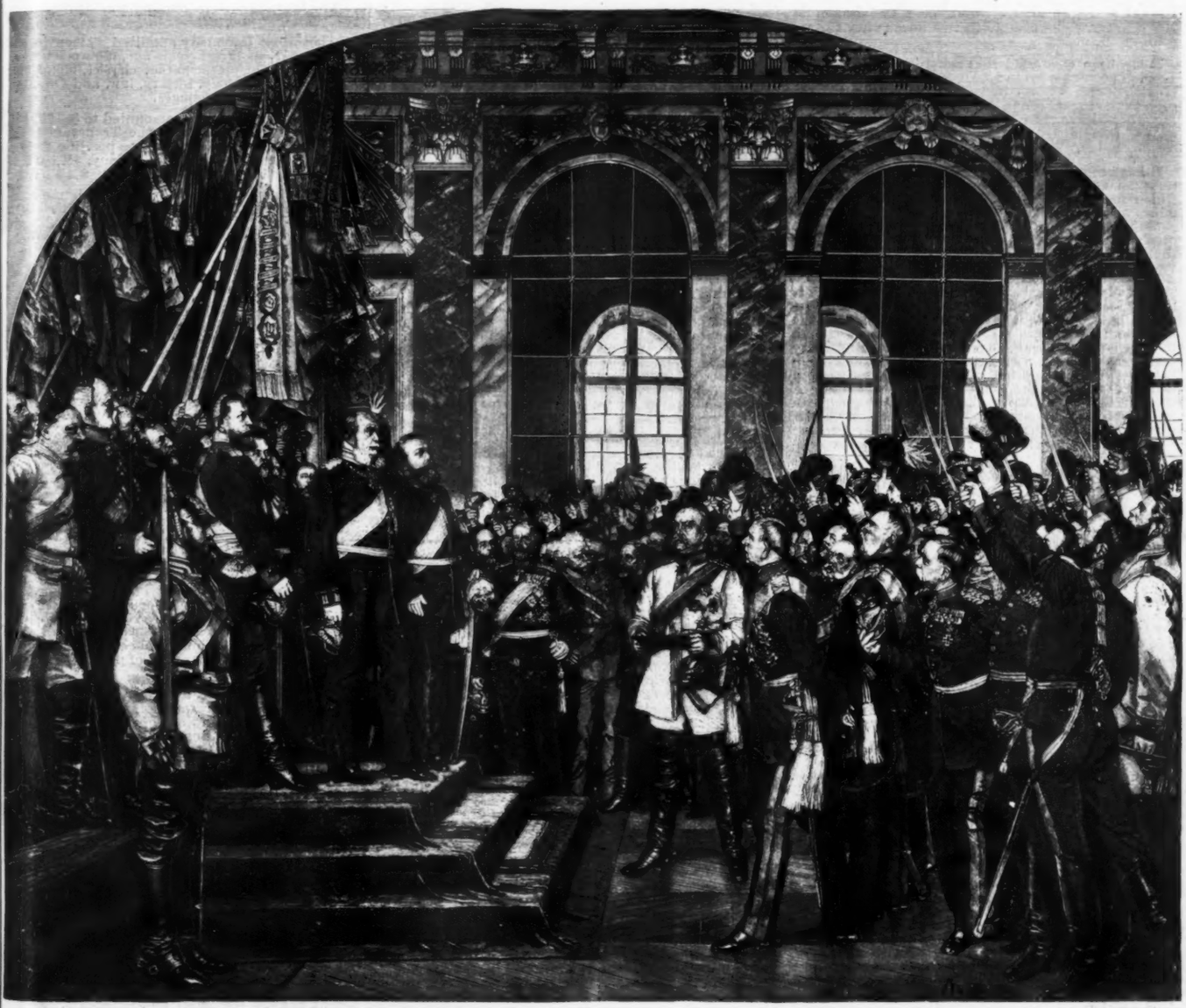
Next in importance come the fourth-class battle ships of the Siegfried class, of which there are eight. They were originally designed as coast defense ships, and were intended for the protection of the North Sea and Baltic Canal; but their excellent performance has shown them to be effective as ships of the line. Their dimensions are: Length, 240 ft. by 49 ft. 3 in.; draught, 17 ft. 9 in.; and displacement 3,500 tons. Twin screw engines of 4,300 horse power give them a speed of 16 knots. They are protected by a complete belt 9·4 in. thick, and by a 1·37 in. steel deck. The two covered barbettes are of 8 in. steel. The forward barbette carries two 9·4 in. Krupp guns, and the aft barbette one gun of the same caliber. There are six 3·4 in. quick fire guns in the central battery, protected by shields; and there are four torpedo dischargers. The high speed and identical dimensions of these little battle ships constitute them a very effective second line of defense. The ships above mentioned have all been launched since 1890, and they are thoroughly up to date.

Of the older ships there is the Oldenberg, launched in 1884, of 5,200 tons displacement and 18·5 knots speed, and carrying eight 9·4 in. guns; the Sachsen class, launched between 1877 and 1880, of which there are four ships having a displacement of 7,400 tons, 14 knots speed, and carrying six 10·2 in. guns in a central battery; the Deutschland and Kaiser, launched in 1874, of 7,676 tons, 14½ knots speed, and carrying eight 10·2 in. guns and 5½ in. guns; the König Wilhelm, launched in 1868, of 9,757 tons, 14·7 knots speed, and carrying twenty 9·4 in. guns; and eleven gunboats, launched in 1878, of 1,109 tons displacement, 10 knots speed, and each carrying one 12 in. gun.

The German navy is weak in cruisers. Her most notable ship is the Kaiserin Augusta, of 6,052 tons, 20 knots speed, and armed with twelve long 5½ in. guns. She was launched in 1892 and will be familiar to Americans as figuring in the naval review at New York during the Columbus celebration; the Gefion displaces 4,108 tons and has 20 knots speed, and carries eight 5½ in. and ten 4 in. guns; the Irene and the Prinzess Wilhelm, of 4,400 tons and 19 knots speed, carry four 5½ in. and eight 4 in. guns and were launched in 1887. Three other second-class cruisers are also projected. There are altogether 48 unarmored ships built or projected in the German navy, and of these 9 were built previous to 1880 and 39 since that date. Outside of the cruisers of which we have given the details, the balance is made up of third-class cruisers of about 2,000 tons displacement and 15 to 16 knots speed.

The German navy possesses a first-class torpedo fleet. When her present programme has been carried out, she will have 11 torpedo boats of from 250 to 380 tons, and 110 first-class torpedo boats. At present she has 140 torpedo boats of over 100 feet length and 16 of 100 feet and less. Many of these are from the celebrated Elbing yards, and have a trial speed of 25 and 26 knots per hour.

Our illustration, for which we are indebted to Black and White, shows a part of the German fleet engaged in evolutions. This very spirited sketch by Mr. Willy Stower is taken from the bridge of the ship which is partially shown to the right of the picture.



THE TWENTY-FIFTH ANNIVERSARY OF THE FOUNDATION OF THE GERMAN EMPIRE.

THE TWENTY-FIFTH ANNIVERSARY OF THE FOUNDATION OF THE GERMAN EMPIRE.

THE recent anniversary of the consolidation of the German Empire would have attracted more attention than it did outside of the Fatherland had the political sky been less overcast, and had the clash of English and German interests in South Africa never occurred. In proportion as the affairs of to-day are of more vital interest than those of a quarter of a century ago, so did the world at large regard the Emperor William's message to the president of a South African republic with an interest which his message from the throne during the recent festivities failed to excite.

The principal official celebration of the twenty-fifth anniversary of the foundation of the German Empire took place in the Royal Castle on Saturday, January 18, with all the pomp and splendor which characterizes every ceremony of the kind at the present German Court.

On his way to the White Hall of the castle, the German Emperor wore the eagle helmet and the chain and robes of the order of the Black Eagle, the imperial insignia being borne in by knights of the same order. Arrived at the throne, the Emperor stood facing the assembly, surrounded by the princes of the royal house, the generals of the army and the chief functionaries of the state. Here he read the message, which had been looked forward to with eager expectation.

At the close of the reading of the message the Emperor, waving the standard of the First Regiment of the Guards, cried out in loud and dramatic tones: "In view of these venerable colors, which have a glorious history of two hundred years, I renew the vow to defend the honor of the people and of the empire both at home and abroad—one empire, one people, one God."

The accompanying illustration, for which we are indebted to Illustrirte Zeitung, is taken from the celebrated painting by Anton von Werner, representing the proclamation of William I as Emperor of the consolidated German Empire. This famous event took place, not, as one would naturally expect, in Germany itself, but on foreign and conquered soil, within one of the great halls of the palace of Versailles near Paris. It was the crowning event of the unbroken series of victories which ended in the siege and capitulation of Paris. Among many other familiar faces will be noted those of the Emperor William I, with his successor Frederick—then the Crown Prince; and below the dais stand the Iron Chancellor, Prince Bismarck, and General Von Moltke, who was responsible for the strategy and general conduct of the war.

A SIMPLE and effective way for preserving wood from decay is used in Switzerland for telegraph poles. A square tank having a capacity of some two hundred gallons is supported at a height of say twenty feet above the ground, by means of a skeleton tower. A pipe extends from the bottom of the tank to within thirty inches of the ground. This pipe is connected with a cluster of flexible branches, which end with a cap having an orifice in the center. Each cap is clamped on the lower or larger end of the pole, so that none of the liquid can escape from the pipe except by passing into the wood. The holes are arranged in parallel lines sloping downward and troughs run under them to catch the drippings. The tanks are filled with a solution of copper sulphate and the wood becomes impregnated with this solution by the pressure produced by the fall. The posts are then removed and dried.

ENGINEERING NOTES.

Aluminum.—It is said that the output of aluminum for 1895 was about 850,000 pounds, and in the United States for 1885 was only 263 pounds. The present price of 98 per cent. pure aluminum is from 50 to 55 cents per pound according to the quantity purchased.

A dispatch from Christiania, Norway, states that the estate of Hafslund, near the Sarpsfos waterfall, has been purchased by capitalists who intend to utilize the falls for the electrolytic manufacture of aluminum. The fall is 74 feet in height and is 116 feet in width.

Messrs. Yarrow & Company were given an order for the stern wheel gunboats Mosquito and Herald, on April 1. On May 5 the trial trip took place. The construction occupied twenty-five working days. In 1893 the same company built a shallow draught gunboat in twenty-three working days.

On January 23 of this year, the Bethlehem Iron Company shipped to New York the connecting rod for the steamship Saale, of the North German Lloyd Line. The rod weighs 10,000 pounds and was one of the quickest jobs in steel work ever undertaken in this country, being completed two weeks after the receipt of the order.

It has been computed that a fog costs the city of London from $250,000 to $500,000 a day. A large proportion of this is borne by the railway companies. As soon as the fog descends, the trackmen, without waiting orders, leave their work, and undertake the duties of fog signalmen. For this they receive an extra shilling a day.

It has been found that soft wood becomes stronger under pressure than hard wood. A piece of pine which formed one of the supports in the Comstock mines was examined and found to be so hard that it could not be cut with a knife, and some other pieces of pine have been so compressed by the great weight that the specific gravity exceeded that of lignum vitæ.

A small percentage of aluminum added to babbitt metal gives an alloy which is said to give superior results. It has been found that the influence of the aluminum upon the ordinary tin-antimony-copper babbitt is to very considerably increase the durability and wearing properties of the alloy. Under compressive strain aluminum babbitt shows itself to be a little softer than the ordinary babbitt metal. A sample 1¼ inch in diameter and 1¼ inch high began to lose shape at a pressure of 12,000 pounds. A similar sample of ordinary babbitt metal did not begin to lose shape until a pressure of 16,000 pounds had been applied.

Winding Steam Pipe with Wire.—The plan of winding steam pipes over eight inches in diameter with three-sixteenth inch copper wire, thus nearly doubling the bursting pressure, is an important change in engineering practice. In order that the thickness of sheet copper forming the pipe may be reduced to the minimum, and at the same time insuring the full advantage of wire winding, an improved system of manufacturing steam pipes has been devised, described as consisting in simply using copper of the thinnest possible gage to form the interior or core of the pipe, while the body proper is composed of steel wire wound closely around the core, the interstices being filled in solid with copper by electro deposition.

Knobbled iron is made from charcoal pig iron which is treated to a second refining process of being heated with charcoal. The iron is run into a cast iron trough after it has become sufficiently refined and the slag then comes to the top and may be separated by scraping after water has been thrown on the surface. The iron is then broken into small pieces and placed in a sunk furnace with charcoal; the cold blast being applied. The iron melts and thickens in this furnace under the influence of the oxidizing blast, and is then rolled into large balls and thoroughly hammered. The blooms are rolled into break downs or slabs and these are repiled and rerolled into what is called skelp iron, from which boiler tubes are made.

A German engineer, named Boedecker, has devised a means of deadening the noise caused by trains in passing over iron bridges. He puts a decking of 1¼ inch planks between the cross girders resting on 3 inch timbers laid on the bottom flanges. On these planks a double layer of felt is laid which is fixed to the vertical web of the cross girder. At the connections with the girder a timber cover joint is placed on felt and two hooked bolts connect the whole to the bottom flange. The decking is then covered with 4 inches of sing gravel, which is inclined toward the center of the bridge for drainage purposes. A layer of felt is laid between the planks and the timbers they rest upon, and all of the iron work in contact with this decking and ballast is asphalted. It is said that the decking weighs only 600 pounds per yard for a bridge that is eleven feet wide, and the cost is only 23 cents the square foot. The bridge is watertight and the noise is considerably deadened.

An interesting comparison of the cost of operating street railways by different forms of motive power is given in the report of the Chicago City Railway Company, which has 162 miles of lines in the south division of the city, namely, horse car 9 miles, cable 34 miles, electric 117 miles. The cost of operation for each car mile in the last two years was as follows:

	1895. Cents.	1894. Cents.
Cable lines	10,240	9,972
Horse car lines	30,550	25,393
Electric lines	14,776	16,904
All lines	12,796	13,487

The relatively high and increasing cost of operating horse car lines, says the Railway Age, is doubtless due largely to the small mileage and light traffic of the roads of this kind now remaining. The decrease in cost of electric lines is noticeable, although with far greater mileage they are still much more expensive to operate than the cable roads.

ELECTRICAL NOTES.

The developed power that is in use, and will be used during this year, from the Niagara River is estimated at 29,226 horse power.

The Electrical Review states that: "It is not generally known that Samuel F. B. Morse was one of the earliest American photographers. About 1841 he and several of his friends opened a daguerreotype studio at No. 7 Bowery, New York City."

For the year ending December 31, 1895, the Edison Electric Illuminating Company report their gross earnings as being $1,563,778, an increase of $161,767 over 1894; operating expenses $759,472, an increase of $84,602; and net earnings $804,305, an increase of $77,164.

Plowing by electric power has been successfully attempted at Rostock, Germany. An alternating current at 2,000 volts was used; it was transmitted from the city station to a farm three and a half kilometers distant, where it was transformed down to 220 volts. Two electric motors, aggregating 25 horse power, were used, and the power was transmitted by wire ropes to the plows.

Wires which carry electric currents at high tension are liable to be a fruitful source of mortality among the trees through which they pass. The constant friction of the boughs against the insulating covering in time wears it off, and in rainy weather the current is liable to pass down through the tree to the earth. The surrounding boughs, twigs, etc., should be carefully cut down in the case of all wires which carry such currents.

The Engineering and Mining Journal reports that Mr. R. Zuloaga, who is a member of the Compania Anonima la Electricidad, of Caracas, Venezuela, has visited the Niagara Falls power installation in company with a representative of the Westinghouse Electric Company. His company contemplate developing power from two falls of El Guaire River, the power to be transmitted to Caracas and used there. The head of the falls will allow the development of 3,000 horse power.

Barnegat Lighthouse, on the Jersey coast, is soon to be equipped with the most powerful electric light in the world. Visitors to the World's fair will remember the great search light which was on exhibition. This was subsequently purchased by the goverment for use at Fire Island; but has been since allotted to Barnegat. It will stand 165 feet above sea level. The old light was visible for 19 miles. This will have a much wider range, and will have greater penetration in thick weather.

The Electric suspension railroad is attracting much attention in Germany, and especially in Berlin, where it is said that the municipal authorities are disposed to adopt it for city lines. The trial line in the suburbs of Cologne has proved very successful, and when the new line on this system between Leipsic and Halle, a distance of 22 miles, is opened, it is proposed to reduce the running time from the present 35 minutes to less than 20 minutes. The system is the invention of Eugene Lanzen of Cologne.

Mr. David L. Barnes, in his testimony as an expert before the New York Rapid Transit Commission, stated that the employment of electric locomotives would save 50 per cent. of the cost of operation. Twenty six-car express trains with motor would cost $330,000; 150 four-car local trains would cost $1,720,000; copper conductors, power stations, and other items would bring the cost of electrical equipment up to $4,649,000. He estimated the speed at 17 miles per hour below and 40 miles per hour above Franklin Street.

Electric railway equipment is rapidly overtaking the steam roads in the matter of weight and size. The Belt Line engines are as heavy as the modern steam locomotive, as are the recently completed Westinghouse-Baldwin electric locomotive and the Heilmann locomotive in France. We now learn that the Chicago General Railway Company has recently purchased five new cars, which are 41 feet long, have at each end 5 foot vestibules, and can seat forty-four persons. There are two four-wheeled trucks to each car, and each truck carries a 50 horse power motor.

The Leeds Town Council, acting upon the report of Dr. John Hopkinson, who recently visited this country and made an examination of various systems of electrical traction, has decided to adopt the closed conduit system for the central portion of the Leeds system of electric roads. This is being done to avoid the use of overhead wires in the business portions of the city. The use of cars which have to take power from an overhead conductor in the suburbs, and from an underground conductor in the city, prohibited the use of the open conduit with its accessory "plow."

The Guest-Bates self-lighting buoy consists of a hollow air-tight ring, such as is common to life-saving buoys, which is pivoted within a light frame of hollow tubing. At the bottom of this frame is an electric battery, from which wires lead within the tubes to an incandescent lamp at the top of the frame. When the buoy is thrown overboard the frame assumes an upright position, and in so doing automatically closes the circuit between battery and lamp. The buoy also carries an automatic oil distributor, which smooths the sea in the immediate vicinity, and facilitates the rescue.

The first electric locomotive manufactured under the joint arrangement between the Westinghouse Company and the Baldwin Locomotive Works has recently been completed. In appearance it is not much different from an ordinary passenger car. It is carried upon two four-wheel trucks, the wheels of which are 42 in. in diameter. There are four 200 horse power motors, one on each axle; so that the whole weight of the locomotive will be available for adhesion. When completely equipped it will weigh 160,000 pounds. Speed trials will develop interesting results in comparison with steam practice. The upper body of the locomotive is 9 ft. wide by 38 ft. long, and can be utilized as a freight or bag age car. These locomotives are designed so that they can be utilized for any of the various systems of electric traction.

MISCELLANEOUS NOTES.

The total amount of steel used in new buildings in New York last year is estimated at 60,000 tons, and it is said there are now plans being prepared for this year that will require 40,000 tons.

A stick of timber 119 feet long and 22 inches square, without a knot or blemish, was cut in a mill at Hoquiam, Wash., last week. It is the longest piece of timber ever cut in that neighborhood.

Twenty-six inches of rainfall in a single storm was recently recorded in Queensland, Australia. The same country was shortly afterward subject to a heat wave in which the thermometer ranged from 110° to 125° Fah.

The Bruce photographic telescope, recently shipped to the Harvard Observatory in Peru, is said to be the largest photographic telescope in the world. The aperture is twenty-four inches and it has a focal length of eleven feet.

The lowest temperature in New York City during the past twenty-five years was recorded on Monday, February 17, when the thermometer fell to 6·4 below zero. The lowest previous reading was 6·0 below, in the two years 1875 and 1881.

Since Cambridge University admitted women to the honor examinations fifteen years ago, 659 women have obtained honors in mathematics, classics, moral and natural sciences, theology, history, law, and Oriental, mediæval and modern languages.

Cape Colony imports in 1895 amounted to $95,000,000, the exports to $85,000,000, and the Transvaal trade amounted to $21,600,000. The corresponding figures for 1894 were: imports into Cape Colony, $58,000,000; exports, $69,000,000; and Transvaal trade, $14,500,000.

Perhaps the most remarkable feat of "house moving," if we bear in mind the nature of the materials in the building, is that recently reported from Chicago, where "a large stone church with a massive square tower was jacked up from its foundations and moved a distance of fifty feet to another lot."

The Australasian publishes an account of the wonderful artesian wells which have practically created new provinces in Queensland. The first bore was begun in 1885, and after sinking to a depth of 663 feet a jet of water yielding 300,000 gallons daily shot up. Nineteen bores have been made at the public cost, and private enterprise is responsible for two hundred and ninety-five.

The Board of Trade return of shipping casualties on or near the coasts of the United Kingdom during the year ended June 30, 1894, gives the total number as 4,951, an increase of 1,452 as compared with the previous year, although only an increase of 241 as compared with 1891-92. The total number of lives lost rose from 275 to 821. Life was lost in 179 out of 4,951 casualties. The collisions numbered 1,429, an increase of 144.

Dr. Sinclair Tousey, in the New York Medical Journal, attributes sea sickness to irritation, which "is probably a reflex from the visual apparatus, or from the semicircular canals of the internal ear. The functions of both these are correlated in the faculty of equilibrium, and the functions of both are greatly overwrought under the conditions of incessant and violent motion which produce sea sickness." He says that "the treatment" which he has "employed with perfect success is the administration every half hour of two teaspoonfuls of a preparation of peptone in sherry wine."

Mr. Leonhard Stejneger, a former associate of Dr. Nansen when the Doctor was curator of a museum in Norway, and who is now one of the curators of the United States National Museum, speaking of the possibility of finding land at the North Pole, says: "We know that there is land further north than any one has yet been, because birds flying north of the limit of explorations raise their young and return with them. These birds do not breed their young on ice; they must have land, and because they do go north and breed is very good reason for believing that land is to be found there."

Few people are aware of the fact that the site of Johannesburg and a large tract of the surrounding land was once bought for $1050. But such was the case, and the purchaser now lies a confirmed invalid in the workhouse infirmary at Guildford. The old man seems to have had a most remarkable career, having been in the service of the old East India Company, fought in the Crimea, being seriously wounded at the siege of Sebastopol, and afterward passed through the Indian Mutiny. He then went to South Africa, when he fought against the Zulus and the Boers. Before the Transvaal was made over to the Boers he purchased for $1050 some 15,000 acres of land near the source of the Crocodile, better known as the Limpopo, where he made up his mind ultimately to settle. But war broke out, and he took up arms against the Boers and formed one of the party who held Pretoria. In 1880, when the republic was declared, he refused to accept service under President Kruger, the result being that his land, now estimated to be worth many millions sterling, was forfeited.—Jersey (England) Press.

A European correspondent of the New York Sun states that it is reported from the Berlin Photographic Club that photography in colors is a fully accomplished fact. Dr. Selle, of Brandenburg, the author of the process, bases it upon "the three primary colors of Helmholz, that is, three colors which, combined together, must produce a pure white. The primary colors which he uses are crimson, pale yellow and a peculiar blue-green. He takes three photographs of an object, the first with all except the red rays cut off, the second under yellow light and the third with blue-green. The photographic positives are taken upon exceedingly thin films, which are stained each with its aniline color. The three films are pasted over each other, and the result is an exact reproduction of the colors of nature in the original object. The results which Dr. Selle exhibited are said to be wonderful. Dark red roses photographed from nature had even the rich peculiar violet hue which the artist with brush and palette despairs of reproducing."

RECENT IMPROVEMENTS IN AMERICA AND EUROPE IN THE STORAGE OF ELECTRICITY.*

By HERBERT LLOYD.

DURING the ten or fifteen years that cover the period during which storage batteries have been more or less in commercial use, the electricians of this country have been divided into two distinct classes, and two only—those unalterably opposed to their use and the other class firm believers and, one might say, enthusiasts.

In Europe one gets the impression from an acquaintance with electrical engineers, in England, France, and Germany, at any rate, that accumulators are considered an essential feature in almost all electrical work Some engineers are greater advocates than others of the system, but all are apparently believers. When it is borne in mind that the discovery of secondary currents was made in 1801, and even a lead accumulator was made in 1803, it seems strange that it has only been within the last five or six years that a lead accumulator has been proved to be a commercial piece of apparatus.

A really practical storage battery was, of course, made by Planté in 1860, and another step was made in 1881, when Faure and Brush developed the battery plate made by the application of already formed active material. About 1890 the chloride plate was developed, differing both from Brush-Faure and Planté. This plate depends for its usefulness on the peculiar and beautiful crystalline structure of the cast material. Although the present state of the art shows more than one excellent form of positive plate, there has nothing yet been produced comparable with a chloride negative plate. Its capacity for weight and ability to withstand both the use and abuse which a battery to be successful must withstand is almost phenomenal.

In England and France the companies doing by far the greater portion of the business use no negative but a chloride negative, and in those countries there are no fundamental battery patents in existence to-day. In England one is impressed not perhaps with the magnitude of the battery installations, but by their number. Private house plants run by gas or gasoline engines are abundant. Central station batteries are being installed about as fast as central stations are built, which in England is comparatively slow. In Manchester, London, and Belfast, Ireland, very large central station batteries have been installed within the last year. The three stations just mentioned were equipped, respectively, by the Chloride syndicate in Manchester, the Epstein in London and the Electric Power Storage in Belfast, the bulk of the business being done by these three companies. During the time I spent in England the Chloride syndicate got ten successive contracts, which were about all that were given out within that period, the fact of their having strong patents covering the only practically perfect negative plate giving them very great advantage. The combination of this negative with the best known positive produces the most effective battery obtainable.

Electric traction, of course, in England and on the Continent is carried on on a very small scale, either trolley or battery traction. In Birmingham, England, a storage battery road has been in operation for some six or seven years, and has been the experimental ground for almost all makers of battery, and the service rendered was, of course, not the most satisfactory. A little over a year ago the Chloride syndicate got a contract for the equipment of all the cars of this line with their battery, and with the experience of their allied company in France at their back, they have been entirely successful, giving service satisfactory to the railroad company and doing the business at a profit to themselves.

In France the Madeleine and Saint Denis road has now been in operation over three years, running some thirty 22 foot cars, double decked, seating between fifty and sixty people. These cars have run up to this time between two and three million car miles, and the company has every prospect of gradually replacing the horse cars in Paris, in the face of the most terrific competition with steam motors, compressed air motors, gas motors, and I do not know how many more. On this road some very good results have been obtained in what they call "recuperation." A very careful test covering 100 trips, about 11 miles each, gives following results, according to figures given by M. Sarcia:

"The car while descending a 10 per cent. grade could recover 57 per cent. of the energy expended in ascending it; on a four per cent. grade a return of 42 per cent. is effected, and on a two per cent. grade 23 per cent. On a one per cent. grade the recuperation is zero, with a traction coefficient equivalent to 22 pounds per ton. If the traction coefficient could be reduced to 11 pounds per ton, there would be recovered, in utilizable form, according to their experience, 63 per cent. of the energy expended in ascending a 10 per cent. grade, and with that low coefficient of traction 23 per cent. could be recovered down a one per cent. grade. If the traction coefficient was zero on the level, the car having no dead resistance, either electrical or mechanical, there would be recoverable on descending a two per cent. grade 70 per cent. of useful energy, the efficiency of the battery being in this case 70 per cent. An electric mountain railroad recently built on the Isle of Man, on which the grade is almost a uniform 12 per cent., is equipped with a trolley system having a battery in the power house. On this road the car descending the grade delivers back to the battery over the line about 33 per cent. of the energy which it consumes in ascending, so that it is beyond question that these applications should be taken advantage of wherever it is possible, the economy being so apparent."

The cars that have been in operation on the Paris roads for three years are of the old type, with the batteries placed under the seats, but new cars are being equipped with one box of batteries suspended under the car, thus eliminating the many disagreeable features incident to locating the batteries under the seats. The practice heretofore has been to run 33 miles on one charge, with a battery weighing about three tons. With the newer cars the battery weighs about 1¼ tons and runs one 11 mile trip on a charge, although under good conditions it would be capable of two such trips. In the new cars no mechanical brake is used at all, the braking being accomplished by the charging of the battery, although for the final stop the motor armatures are short circuited. The motors are shunt wound, always used in multiple, and in starting resistance is inserted in the armature circuits, which is gradually removed to increase the speed until it is all out. To attain full speed, the field is weakened by inserting resistance.

The matter of charging the batteries on this road has received very careful attention, and has been modified at various times. Originally, when the road was started, the battery was charged at a constant potential, 108 cells being thrown on to a 260 volt bus. Under these conditions, the charging current commenced above 150 amperes, but gradually decreased, so that at the end of charge it had reached about 10 amperes. They now use two buses. The battery is thrown on to a bus equivalent to 2·4 volts per cell, where it is left for three hours, or until the current has fallen from 90 to about 30 amperes. At the end of the third hour the battery is thrown on to a higher bus, equivalent to 2·55 per cell, on which the charge is completed in from one to two hours more, thus avoiding the use of resistance.

The most interesting feature in connection with the operation of this road is in the method of repasting the positive plates. The positive support plate is grooved and made of an alloy, upon which there is very little electrolytic action, and by a special process the peroxide which has been deposited on the bottom of the jars in a worn out cell is repasted into these grooves. Two men are employed repasting and are able to keep some 30 cars in continuous service, so that the cost of this portion of the operation is wonderfully small. I saw a number of these grids which had run between 25,000 and 50,000 miles, showing no evidence whatever of depreciation. The casting of these grids is carried on by a special process, by which the alloy is cast under very heavy air presure, which method is protected by an original American patent, the French patents of which have been assigned to the French Chloride Company.

In a five-wire station at Paris two very large batteries were being installed last fall, one-half being manufactured by the Chloride Company, the other half by the Tudor Company. The battery, which is now complete, is probably one of the largest in the world.

In Germany, the Tudor Company, with works at Hagen, has, during the past eight years, installed over 5 000 plants. A most interesting application of storage battery has just been made by it on the street railroad of Hanover, where the cars are propelled by storage batteries within the city limits, and run by the trolley outside, the battery being charged without removal while the cars are running through the outskirts.

Forty-four cars have been installed on this plan. Battery cars are also running in Berlin, Hagen and other German cities, and also in Vienna. Up to the past year the German Tudor Company has devoted its attention almost entirely to lighting work, but in Germany and France there is a feeling that the time is ripe for the development of storage battery traction and within the next year a great deal will be accomplished in this line.

It is well known that in this country patent litigation has long interfered with the development of the storage battery business. Something over a year ago one strong company acquired all the patent rights of the contending companies, thus removing all question on the score of patents. This company, being also allied with the three strongest European companies, is able to take advantage of every improvement that is made either here or abroad, and can therefore produce the best battery obtainable.

Some months ago the New York & Harlem Railroad Company, of this city, decided to place two storage battery cars on its Madison Avenue line, to be operated through the winter, in order to determine whether or not the system has been brought to a stage of advancement which would warrant the equipment of the entire road.

In the cars run from Eighty-fifth Street to One Hundred and Thirty-fifth Street the batteries are suspended between the axles, on the car truck, entirely independent of the car body. In fact, so independent are the trucks that they have been run alone without any car body on them at all.

The cars have standard Stephenson bodies 18 feet long and standard Peckham trucks. Sixty cells of nine plate traction type chloride accumulators, capacity 400 ampere hours, are placed in a tray about 4¼ feet square and connected up solidly by lead burning in two series of 30 cells each. This tray is placed on a small transfer truck, running on a narrow gage track in a pit 8 feet below the level of the street car tracks. An electric elevator is utilized to hoist the tray full of batteries, together with transfer truck, up between the street car rails into position on the street car truck, where the tray is automatically locked and the elevator, with transfer car, withdrawn. Large contact shoes on the car, kept in place by steel springs, engage with contact plates on the trays, as batteries are raised, so that the connections are made automatically.

Each car is equipped with two G. E. 800 motors, supported outside of axles, and two "K" controllers, giving combination as follows: First, batteries parallel, motors series; second, same with shunt field; third, batteries series, motors series; fourth, same with shunt field; fifth, batteries series, motors parallel; sixth, same with shunt field. A cable system will be applied to the shifting of the transfer cars in the battery pit.

The special advantages of this particular method of battery application include the features before mentioned of low steps for cars and the standard height and width of seats; an entire independence of car body permitting of a change, as, for instance, from open to closed car bodies and vice versa, together with an entire absence in the car of odor from the battery electrolyte; a compact, easily handled tray of batteries; utilization of space below and above the street car floor, without occupying one square foot of the car shed proper.

In the past batteries were made of a practically uniform type of small size, capacity being obtained by putting many series of cells in multiple. Now, large units in batteries have come into use, just as large generating units have, an example of this being the battery installed in the Boston Edison Company's station where each cell weighs about 3 tons, capacity 8,000 ampere hours, or 16,000 ampere hours at 140 volts, with a maximum output of 8,000 amperes.

The size of cell could be increased almost indefinitely. Batteries are now constructed specially to suit the work for which they are intended. Until recently in isolated plants, such as private houses, 150 ampere hour cells in glass jars were generally used, as many as 8 of such series being installed in one house. A private house plant has been recently installed in this city with one series of cells of 2,500 ampere hours each, and in the last three months half a dozen similar plants have been installed, varying in size from 1,000 ampere hours up.

Within the last year the question of electric train lighting has come up with considerable force, and cars are now running between New York and Chicago lighted by storage batteries alone, without any systems for operating dynamos and engines on the train. Train lighting in this country is a different matter from train lighting in Europe. In Europe a few 8 candle power lamps to the car are considered sufficient. The cars just referred to as running between New York and Chicago have 44 16-candle power lamps. A train consisting of 5 or 6 such cars requires a lighting plant of quite serious proportions.

Experiments are being made with more or less success with small dynamos driven from the axle of the car; a moderate sized storage battery is used to maintain the lights when the speed of the train falls below some 20 miles an hour. A car so lighted is now running satisfactorily between New York and Washington.

Perhaps the application of storage batteries which will arouse greatest interest is that of stationary batteries applied to equalizing the load on trolley lines. Two or three plants of this character have been installed within the past year. In a road of considerable length the application of a storage battery would save in feeder copper a great deal more than its own first cost, and the contingent advantages to be derived from the operating of the generating plant at a practically constant load are too well known to require reiteration.

The application of batteries to electric elevator installations shows as great or even greater advantages. As Mr. Sprague stated in his paper before the last meeting of the institute, to operate 6 elevators without a battery would require a 120 kilowatt generating plant, while the average load would be but 35 to 40 per cent. of this. With a properly constructed battery he states that the direct plant could be reduced to 60 kilowatts, or even to but 50. A battery was installed last fall in connection with the elevator plant in the new court house in Minneapolis, and the curves shown proved the effect. A similar plant is just being installed in the Chicago Board of Trade building for the same purpose.

In this class of work it is necessary that the battery should be capable of discharging at rates which would completely exhaust it in from half an hour to an hour. These discharges, of course, are not long continued, and the batteries as now constructed are not injured by this treatment. Up to two or three years ago a 10 hour rate of discharge was considered a maximum rate. Recent improvements in the manufacture of storage batteries have been entirely along the line of producing a battery which is capable of discharging in from 1 to 3 hours, and although the cost has not materially decreased, if capacity alone is considered, when discharge rate is considered the cost has been greatly reduced, since a battery which can be discharged at five times its normal rate will replace one five times its size of the old type.

One feature of the battery business which has received a good deal of attention recently is the specific gravity of the electrolyte. The curves shown are very interesting, as they show how the capacity of a cell varies with the density of the electrolyte, the plates being respectively ¼ inch thick and ⅛ inch thick. The thicker plate has a maximum capacity when the density of the acid is about 1.275; the ¼ inch plate has a maximum capacity when the electrolyte is about 1.240. It is very noticeable how rapidly the capacity falls off on either side the maximum point. These curves are taken from two chloride cells, the volume of the electrolyte being sufficient to prevent any great change in specific gravity. The mean volts on discharge shown in the upper curves rise almost regularly as the acid density rises.

The rate of discharge being the same per pound of active material, the discharge rate per superficial area is, therefore, approximately 40 per cent. greater with the thick plate than with the thin.

The battery just being installed in the new Edison station at Twelfth Street, this city, consists of 150 four thousand ampere hour cells. The positive plates of this battery somewhat resemble the Tudor type; the negatives are the chloride type. They are installed 75 cells on each side of three-wire system; the 25 end cells on each side are used as regulating cells, being connected by copper bar to 4 regulating switches, 2 on each side, so that the battery can be discharged at different potentials.

The battery has a capacity at 10 hour rate of 4,000 ampere hours on each side; at a 3 hour rate of 3,000 ampere hours on each side, and at 1 hour rate of 2,000 ampere hours on each side.

The erection of the battery in two tiers, the upper tier of iron framework, is perhaps new in this country. The installation of the cells is effected by a special type of oil insulator, which makes this method of erection quite safe.

The battery is installed in a room approximately 20 feet by 40 feet, which is, I think, the smallest space in which a battery of equal capacity has yet been placed.

Another Edison station recently equipped is in Lawrence, Mass., where a smaller battery with capacity of about 1,500 ampere hours is in use. This battery is discharged completely in two hours, between four and six in the afternoon, during the peak of the load.

The carriage which secured the gold medal, first prize, in the horseless carriage contest, in Chicago, was built by Caffrey, of Philadelphia, and weighed complete 1,650 pounds, including a battery weighing 664 pounds. The battery consisted of 44 50 ampere hour chloride cells; the wagon was equipped with two 1½ horse power Lundell motors with series parallel controller.

The carriage is capable of running from 25 to 30 miles on one charge at a speed of 10 miles an hour; it could

* Read before the New York Electrical Society, January 29, 1896.

attain a maximum speed of about 20 miles an hour for one hour, carrying four people. The two front wheels of the carriage are driving wheels and it is steered by the rear wheels. On the first speed, with an average discharge of 5·6 amperes, or ⅝ of an electrical horse power, a speed of 4·6 miles was attained, and at this speed the carriage would travel 46 miles on one charge. On the second speed, running at 10 miles an hour, it required 13·2 amperes, or $1\frac{5}{100}$ horse power, covering by this speed about 30 miles on one charge. This carriage has been sold and shipped to Germany to be used as a model for building similar ones over there.

This question of electric vehicles is attracting the attention of the large carriage and bicycle manufacturers, many of whom are building such vehicles, and with a battery such as is now produced, capable of very heavy discharges, and with good roads, it would appear as though the business would soon assume large proportions.

The use of electric launches is growing steadily, but not as rapidly as other applications. In this work light weight is not so important as for carriage work, but batteries for this work must have large capacity, as it is often necessary to make long runs before facilities for recharging can be obtained.

The improvement in storage cells for this work is shown in the fact that the batteries on the launches which ran for three months at the Atlanta Exposition did not cost one cent for repairs, which was not the case with those used at Chicago at the World's Fair. The battery used at Atlanta was the chloride type.

[ENGLISH MECHANIC AND WORLD OF SCIENCE.]

APPARATUS FOR COPYING AND ENLARGING BY PHOTOGRAPHY.

By A. P. WIRE.

WE must, of course, suppose first of all, that the person wishing to copy an engraving for making a lantern slide has a knowledge of photographic manipulation, and possesses a camera. A beginner in photography would hardly commence his work by copying line engravings.

The apparatus required will comprise a camera and

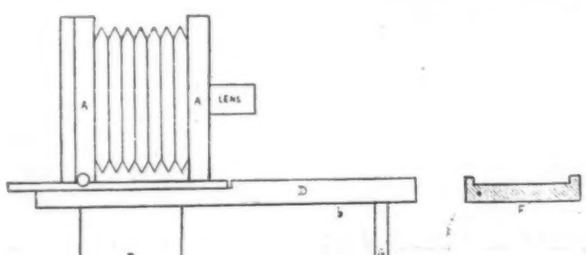


FIG. 1.—Camera on Stand with Extension Board.

lens, a mounting board for engravings, artificial light, if daylight be not used, stand for camera, dishes and chemicals for development, etc. To avoid repetition and for perspicuity, these various subjects will be considered separately under their various heads.

Camera.—If only negatives to print lantern slides by contact are required, a quarter plate camera will do; but a half plate, with non-tapering bellows, seems preferable, and is more generally useful. The camera must be quite light tight. To test this put the camera on the stand, and take it out in the bright sunshine; put cap on lens, close stop slot (with an India rubber band), remove ground glass screen, and having extended the bellows as far as possible, cover the head (but not the camera) with focusing cloth, and look carefully for a minute or so, to see if there be any pinholes in bellows or frame. If light comes through anywhere, the defect must be remedied.

Focusing Screen.—For very fine work such as we contemplate, the focusing or ground glass screen must be anything but coarse. Usually the screens sold with cameras are not so finely ground as might be desired; but a very fine screen may be made in the following easy way: Having a piece of clear glass of the size required—a cleaned half plate will do—lay it on a board; sprinkle some flour of emery on the glass; add a few drops of water, and lay over this another piece of glass; then grind by working the top piece backward and forward and in all directions, using fresh emery and water when necessary, until the surface is evenly

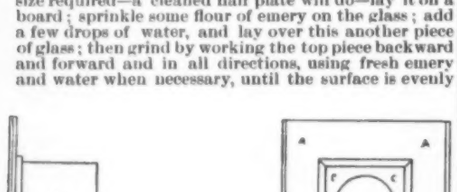


FIG. 2.—New Camera Front, with Box.

ground all over. A wash under the tap will clean all emery away, and when finished the surface will be very flat and finely ground.

Camera Extension.—It often happens that one wants to enlarge a small engraving to make the picture an appropriate size for the lantern. In this case it will be necessary by some means to extend the camera, so that the lens may be at a greater distance from the photo. plate when the latter is in the dark slide and placed for exposure. It will be as well to remember the following principles of arrangement. If our photographic copy is to be of the same size as the original picture, the center of the lens must be equidistant from both photo. plate and picture to be copied. If the copy is to be smaller than the picture, then the distance between lens and picture must be greater than between lens and plate; vice versa, if the copy is to be larger than the original picture, the distance between lens and picture must be less than between lens and photo. plate in camera. The following is a description, with illustrations, of my extension arrangement made at home, and although every way effective, it can be easily made by any one who has a little mechanical ability, and at a small cost.

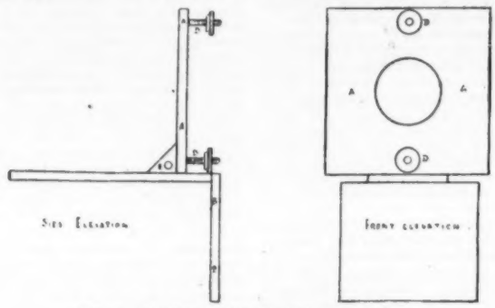


FIG. 3.—Front Extension Board to support Lens.

It may be noted here that this extension can only be made with a camera the lens of which is fixed, and the back of camera containing the ground glass is moved for focusing.

The camera may be mounted as follows: Make the base board extend in front of the camera 10 in. or 12 in. as shown in Fig. 1, where A A is camera, B mounting platform on rail C. D extension of baseboard supported by strut, G, on the edges of which are fastened two fillets of wood, E E, lengthwise, as shown in section on a b at F. Remove the camera front, and fit a piece of mahogany in its place. Cut a square hole of $4\frac{3}{4}$ in. side in this, and fit it to a cubical box with a circular hole in front of $3\frac{1}{4}$ in. diameter, as shown in Fig. 2, where appear in front and side elevation the new front. A A being the substituted front and C C the cubical box.

Front Extension Board for Support of Lens (see Fig. 3).—Take a piece of ⅜ board 14 in. long, and make it just wide enough to fit in easily between the fillets on camera extension board, as at F, Fig. 1. At the end of this dovetail a piece of board at right angles, and make this (B) high enough to stand on the rail, c, Fig. 1, and easily slide backward and forward. Two inches from the end of this mortise a square piece, A A, of the size of the camera front, having a central circular hole of $3\frac{1}{4}$ in. size. Attach to this at top and bottom two screws with brass nuts, as at D D, for fastening the piece carrying the lens flange, and add a triangular piece to strengthen on each side nearest camera, as at E.

Flange Piece.—Cut a piece of ¾ mahogany, 5 by 7, round off ends, cut two slots as at A A, Fig. 4, and make a circular hole the size of the hole in the lens flange in the center, and glue on back strips of cloth, so as to insure a light-tight fit when screwed on. The dotted lines on front elevation show position of strips of cloth on back. The slots, A A, for the screws, D D, Fig. 3, allow the upward and downward motion of the lens. The whole of the parts so far made are shown in position in Fig. 5, where A A is camera; B, new front with cubical box; C, new lens-front, so supported that the optical axis of the arrangement will not be deflected by the lens sinking. It will be only necessary now to fill up the space between B and C in such a manner that the light may be quite shut out, and the distance between B and C easily varied. This was done in the following manner: Two pieces of zinc tubing were made (see Fig. 6) so that B would just loosely fit in A, each 3 inches long, with a flange 1 in. wide, A being $3\frac{1}{8}$ in. in diameter. If any one likes to buy brass tubing, the thing is done; but I always like to make my own apparatus, and turned these up in the following way in the lathe: A piece of thick wood was turned up of the size required, and this block was made tapering. Round this I worked a piece of sheet zinc with finger and mallet, cut the edges clean, brought them together, not lapped, tied with copper wire, and soldered the joint flush, then trued up in lathe; for the second tube, reduced size of block and made B in same way. The flanges were cut in the lathe, soldered on, and the two tubes screwed on as at A and B (Fig. 7), so that by sliding B along the front board, B fits in A easily. By this means the lens can be removed from the plate from $6\frac{1}{2}$ in. to $9\frac{1}{8}$ in. further than before, and as the tubes fit one in the other easily, the distance can be varied at will within certain limits. Wanting still further enlargement, I added another tube as shown at A A (Fig. 8) to fit over the zinc tubes. This is made of brown paper, and a capital adjunct it is, being both very light and strong. It was made in this way: First a block 9 in. long was turned in the lathe, taper, the ends being respectively a trifle larger than the ends of the zinc tubes. Round this was wrapped and lapped and pasted a piece of newspaper, so that it was not pasted to the wooden block. Then, having prepared some good paste, and cut some stout, but not glazed, brown paper into strips about 9 in. wide, these were soaked with water, pasted well, and gradually wound round the block, working smooth with the fingers until the tube was about ⅛ inch thick. After drying, the ends were cut true in the lathe with a chisel, and the block removed by a gentle tap on the smaller end with a mallet. All these tubes must be well blackened on the insides, and this may be done with lampblack mixed with methylated spirit, in which a little shellac has been dissolved.

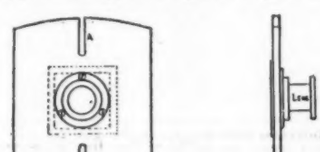


FIG. 4.—Lens Flange-Piece.

As my camera bellows extends 13 in. from lens, and this extra arrangement gives about 16 in. more—in all 29 in.—it will be found sufficient to enable to be enlarged to double the size in linear measurements, and four times the size in area. For instance, a picture $1\frac{1}{2}$ in. square can by this arrangement be enlarged to a square of 3 in. square; if further enlargement be required, a longer tube may be added. If these tubes be not quite light-tight, a focusing cloth covered over will remedy any defect. Fig. 8 shows the complete arrangement.

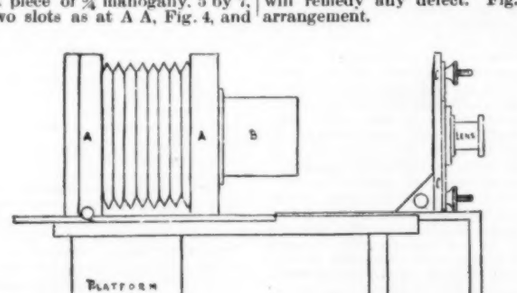


FIG. 5.—Camera with Extension in Position.

Lens.—It is no use trying to take a good picture with a bad lens. If one can afford it, a good lens for the purpose can be purchased of any respectable optician; but guaranteed high class lenses are expensive, and necessarily so, I suppose. What is wanted is to know if any lens we happen to have will do the work. The sort of lens required is what is known as a "rectigraph," or rectilinear lens.

A single lens, or a lens made of one piece of glass, often called a landscape lens, is of no use whatever for our purpose, as it will not render the image of a straight

line as a straight line, but somewhat curved. The rectilineal photo. lens is a compound lens so constructed that it ought to be free from chromatic and spherical aberration.

Chromatic Aberration.—If a lens has this fault, the visual focus will not correspond with the chemical focus; or, in other words, the various rays of colored light which go to make up the white light will not all meet at one point after passing through the lens; but they will meet at various points on the optical axis of the lens, and a blurred picture will be the result. This is roughly illustrated in Fig. 9A, where the rays are shown meeting at all places along the axis from C to D, while in Fig. 9B the rays all meet at the focus, E. No lens made of a single piece of glass will ever be capable of bringing all the rays to one point; but combinations of various kinds of glass are used, and in the rectigraph lens this defect is, or ought to be, overcome.

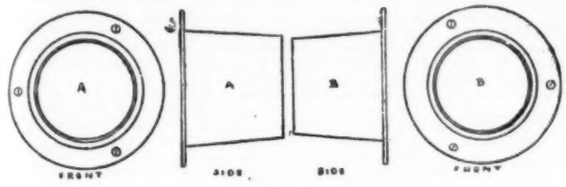


FIG. 6.

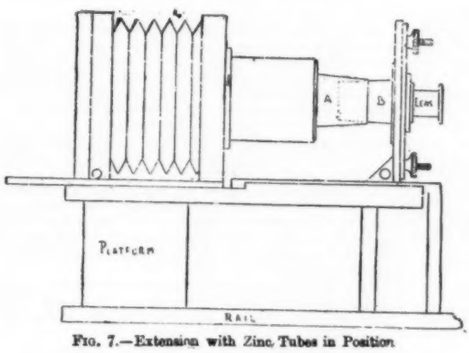


FIG. 7.—Extension with Zinc Tubes in Position.

Spherical Aberration.—When lenses suffer from this defect, the straight lines of any picture are rendered as curved, the deviation from the straight being more or less according to the curving of the surface of the lens. If this spherical aberration be not got rid of, the lens will never copy correctly a fine line engraving. A simple way to test the lens for spherical aberration is to make a diagram like Fig. 10A. On a white board draw a square of 8 in. side in very black lines, and rule very carefully straight lines crossing to divide it into a number of smaller squares. Put this up before the camera as though to photograph it. See that it is quite at right angles to the optical axis: focus and get the largest picture possible on the ground glass. Examine this carefully, and if the lines, especially at the edges, are at all curved like Fig. 10 B, the lens suffers from spherical aberration, and won't do for our purpose.

Having now, we suppose, a good and suitable lens, the next thing to do is to try it. Select some suitable engraving. Put this up for copying in the following way: Fasten it on a drawing board with drawing pins or India rubber bands; the board to be held in a vertical position in a frame or some other support movable on the floor or table and adjusted to permit the light to fall on the copy at an angle. The important thing now is to get the picture at righf angles to the optical axis of the lens, and consequently exactly parallel to the ground glass. If the apparatus noticed above be used and made true, the drawing board will always stand at right angles, and if there be any side play, the better way to get it right is as follows: Prepare a large square of black paper, pasted on a white board, and fasten the picture to be copied in the center. Put the whole on drawing board, and put up to focus. Examine the picture on the ground glass and, using a pair of compasses or strip of paper, measure and shift the picture until the line, A B, on the ground glass is exactly equal to C D and C A to D B. This being done, we are ready to photograph.

Dry Plates.—These are a decided advantage, if for no other reason than that the plates can be exposed one evening and developed at some future time. A good negative for a lantern slide should have good contrasts; the whites of the picture should be in the negative densely black, and the black lines of the picture should be perfectly clear. Special plates are, I believe, sold for this purpose; but I invariably use the Imperial ordinary plates.

Developer.—The following is a good single fluid negative developer that works well, may be made in bulk, and will keep a long time if excluded from the air in well corked or stoppered bottles. It is advisable to make a quart at a time and then decant into smaller bottles. Formula: Distilled water, 40 oz.; sulphite of soda crystals, 1½ oz.; carbonate of potash (dry), 3 oz.; hydroquinone, 100 gr. Prepare this in the following way: Have ready one quart bottle and two pint bottles. Put about 12 oz. of water in each of the pint bottles, and add to one the sulphite of soda; to the other the carbonate of potash, so as to dissolve each separately. When both are dissolved, mix by pouring them into the quart bottle, and fill up with the water. Shake well, then pour it into a jug; rinse out the quart bottle and carefully filter the liquid into the large bottle. When this is done, add the hydroquinone, and always filter immediately before using.

Exposure.—This is now to be done, and the exact time must be ascertained by experiment. The exposure required varies with lens, stop, light, plate and developer. Therefore, keep to the same plates and developer, and when the correct time for exposure is discovered, a great number of plates can be exposed in succession with an almost certainty of good results. In my experiments I find, for a good white and black subject, the Imperial ordinary plates backed, the developer above given, two albo-carbon lights with No. 5 Bray's burners; a little over three minutes is the correct exposure with stop F. 16, my lens being a rectilineal of about 9 in. equivalent focus.

Focusing.—To obtain a good result the focusing must be carefully and accurately done. Use a good magnifying glass, have plenty of illumination, and don't be in a hurry. Focus being right, cap the lens, and put in dark slide with plate. Now as to stop, as there may be a little spherical aberration in the lens the eye has not detected, stop down the lens to F. 16 or F. 22. The smaller the stop, the longer the exposure, and the finer the resulting picture. To find the correct exposure, make the following experiment: See the camera is firmly screwed on its platform, and, having all ready, draw slide so as to expose one quarter of the plate, and give half a minute's exposure, put on cap of lens, draw the slide to uncover half the plate, and give another half minute exposure, cap lens again, draw out to three quarters of plate, and give another half minute, finally draw out slide full, and give two minutes' exposure. By this means the plate will have been exposed in four sections as follows:

No. 1 with 3½ min. exposure, No. 2 with 3 min. exposure, No. 3 with 2½ min. exposure, and No. 4 with 2 min. exposure. Develop carefully and fix, when it will be seen which section of the plate gives the best result, and the correct exposure will be known.

In all experiments of this kind the careful worker makes full notes at the time; the doing so saves time and expense, and the notes are of great value for reference. Copying as I do a great number of drawings, pictures, diagrams, maps, and natural objects, I find it best always to have a note book, and make entries at the time in ink. My notes of taking copies are in this form.

Date.....
Subject.....
Plate (backed).....
Stop.....
Lens.....
Exposure.....
Light.....

For colored objects it is better to use isochromatic plates, and as it is very tedious to count minutes or half minutes on a watch, I use a sand glass egg boiler. This runs through in 3¼ minutes. By letting the sand run a quarter of a minute, and then uncapping the lens, a correct 3 min. exposure is obtained without one wondering as to how long the cap ought to be off the lens.

Developing.—Success in photography depends not so much upon grand and expensive apparatus as attention to little things, one of the most important being cleanliness. See that developing and fixing trays are entirely free from dirt; never put them away without washing and rinsing well. Particles of dust of any kind are great enemies, and, if on the plate, result in pinholes in the film. Keep the dark slides well dusted, and dust carefully every plate before putting it in the dark slide and after it comes out. Always filter developer and fixer immediately before using, and never work in a dusty room.

Having washed the backing off the plate, and thoroughly rinsed both sides so as to get rid of every trace of backing, put plate in developer, and keep the liquid gently moving. The development should proceed equally all over the plate, and, when carried far enough, wash the plate and fix.

Fixing.—Formula: Water (tap water), 20 oz.; sodium hyposulphite, 4 oz. As "hypo" is very cheap, it is better not to use it the second time. Make up a quantity, as it will keep, and so save trouble. Get a large, stoppered Winchester quart, holding about four imperial pints. Weigh out the hypo. crystals, put a funnel in the bottle, and fill this with the crystals. Pour on the warm water and the crystals will very rapidly dissolve and fall into the bottle. Do this the day before the fixer is wanted, and add to the "hypo," about ¼ oz. strong ammonia, which will prevent the solution turning acid. Filter this immediately before using, and keep the plate in motion, so as to dissolve out all the unaltered silver.

By following out these instructions, line diagrams and maps may be copied with success. If the lines do not come out quite so clear as required, try a smaller stop, and increase the time of exposure.

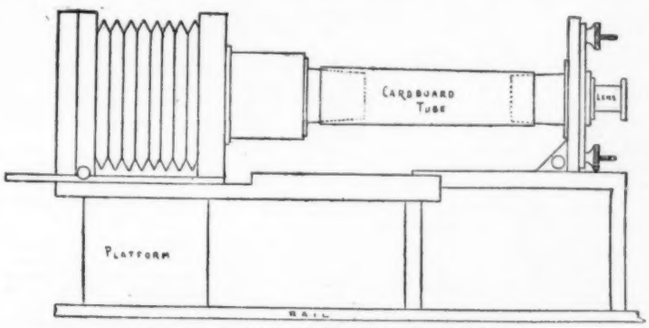


FIG. 8.—Complete Extension with Cardboard Tube.

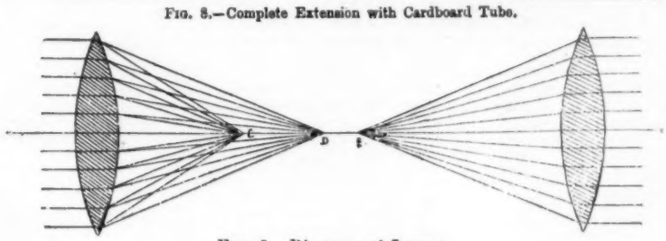


FIG. 9.—Diagram of Lenses.

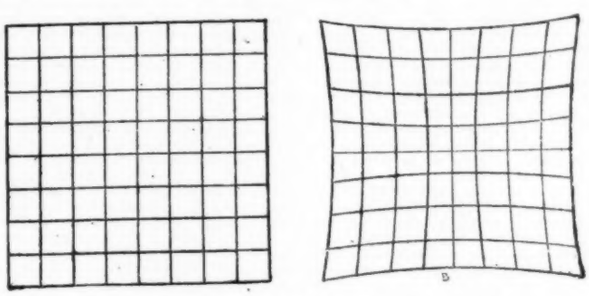


FIG. 10.—Diagram to Show Spherical Aberration.

THREE NEW REAGENTS FOR NITRITES.

By G. DENIGES.

AMONG Griess' reagents, which are being more and more used for the detection of nitrous acid, the salts of meta-phenylendiamine are especially admired. Along with their excellent properties, they possess various defects, e. g., they are attacked by the halogens, by hypochlorites and hypobromites, and their solutions are readily decomposed by air. The author recommends the following reagents which are, in part at least, free from these defects:

1. Phenol, if boiled with Millon's reagent, gives a precipitate which dissolves in acetic acid with a red color. This reaction renders it possible to detect phenol at a dilution of 1:2,000,000. Millon's reagent is a solution of mercury nitrite and nitrate; the effective substance being the mercurous nitrite or nitrous acid in presence of a mercurous salt. Hence, for the detection of nitrous acid the author uses the following solutions: (a) Phenol, 1 grm.; sulphurous acid, 4 c. c.; water, 100 c. c. (b) Mercuric oxide, 3·5 grms.; glacial acetic acid, 20 c. c. water are mixed; ½ c. c. of sulphuric acid is added, and the mixture is filtered. For use, equal volumes of a and b are mixed, heated to ebullition, when 1 or 2 drops of the solution in question are added. If 0·5 grm. nitrite is present in 1 liter of liquid, a red coloration appears.

2. Two c. c. aniline are dissolved in 40 c. c. glacial acetic acid and made up with water to 100 c. c. Of this solution, 5 c. c. are boiled with a corresponding quantity of the liquid in question. (In very concentrated solutions 1 drop is sufficient.) In presence of nitrous acid there appears a straw yellow or a deep orange color, which on cautious acidulation passes into a red. Chlorates and nitrates do not interfere as do hypochlorites, hypobromites, free chlorine, and bromine. An excess of acid may interfere, whence

strongly acid liquids should be previously naturalized.

3. Resorcin, 1 grm.; water, 100 grms.; sulphuric acid, 10 drops. Place in a test tube 10 drops of the liquid to be tested, 2 c. c. of pure sulphuric acid, 5 drops solution of resorcin, and shake up. The presence of nitrous acid produces a carmine red or violet blue solution, which is very intense at 0·01 m. grm.—Journal de Pharmacie and Chemiker Zeitung.

THE STATISTICS OF OCCUPATIONS.*

THE fourth lecture in the special course on the Science of Statistics and their application to industrial subjects, by Carroll D. Wright, was delivered at the School of Social Economics, 34 Union Square, New York, on February 14, and was chiefly directed to the statistics of occupations. He presented in tabulated form the census figures for two years, separated by two decades, showing the total number of people engaged in various occupations in the years 1870 and 1890; and also the proportion of the people so engaged to the total population of the country.

	1870.	1890.
In all occupations	12,505,923	22,735,661
Agriculture, fishing, mining, etc.	6,141,363	9,013,201
Professional service	371,098	944,323
Domestic and personal	2,311,820	4,360,506
Trade and transportation	1,229,390	3,325,962
Manufacturing and mechanical	2,452,243	5,091,669

PERCENTAGE OF TOTAL POPULATION IN OCCUPATIONS.

	1870. Per cent.	1890. Per cent.
In all occupations	32·43	36·31
Agriculture, fishing, mining, etc.	15·93	14·39
Professional service	0·96	1·51
Domestic and personal	5·97	6·97
Trade and transportation	3·21	5·31
Manufacturing and mechanical	6·36	8·13

From this table it will be seen that there are ten and a quarter millions more people engaged in occupations in the United States in 1890 than there were only twenty years before; and that the ratio of all persons thus engaged to the total population had increased by nearly 4 per cent.

It is interesting to note that the percentage of the total population engaged in agriculture, fisheries, and mining is a little less now than twenty years ago. In 1870 it was 15·93 per cent. of the whole, whereas in 1890 it was but 14·39 per cent. This shows that the proportion of the population engaged in those lower walks of labor does not increase. On the other hand, when attention is called to professional service, it is found that while but 0·96 of 1 per cent. of the population were so engaged, in 1890 1·51 per cent. were engaged in professional work. The proportion in domestic and personal service has also increased; while in trade and transportation the advance has been from 3·21 per cent. to 5·31 per cent.; and the increase in manufacturing and mechanical pursuits has been from 6·36 per cent. to 8·13 in 1890. The positive conclusion to be drawn from these figures is that, while in the lower walks of labor the percentage of the whole population does not increase, in the higher—those requiring more intelligence, better equipments, and higher skill—it has increased.

This fact answers conclusively the statement often made in certain quarters against the existing state of society to the effect that the substratum of society is constantly growing larger, while the higher classes are diminishing as they grow richer. Another conclusion to be drawn from these figures is that the presence of machinery does not result in reducing the proportion of the whole population engaged in gainful work. If it did, the percentage of such persons of the whole population, instead of showing an increase, as it has, would have shown a decrease.

Of the total number, 22,735,661, engaged in all occupations, the native born comprehend 17,521,420, or 77 per cent. of the whole. The foreign born number 5,214,241, or 22·93 per cent. of all persons so engaged. Of the whole number engaged in all occupations, Mr. Wright estimates that 15,000,000 are wage earners.

Comparing this country with others, it is found that the total number of persons per each 1,000 engaged in:

	Agriculture.	Manufactures.
Is for Russia	294	65
" Austria	280	81
" Italy	190	80
" Germany	178	118
" France	170	117
" Spain	160	—
" United States	153	81
" Great Britain	73	148

The number of people engaged in agriculture in the United States, relatively to the total population, is less than in any country but Great Britain; but this is largely to be explained by the extensive use of labor-saving machinery in this country. The total number of persons in the whole world engaged in manufactures is 33,539,000, and in agriculture it is 71,750,000.

The productive age, that is from 15 to 70, runs very closely in different countries. Including all persons, male and female, without reference to their occupations, it is found that the number is, in Germany 61·9 per cent. of the total population; in England 61·2 per cent; in France 68·7; in Sweden 62·9; in Italy 64·6; and in the United States 60·1 per cent. Dividing the United States into native and foreign white, we find that of the former 55·6 per cent. belong to the productive age, and of the latter 90·3 per cent:

Statistics of the number of persons dependent upon each 100 males between the ages of 20 and 60:

Spain	388
United States	405
Austria	413
Germany	417
Belgium	418
Sweden	420
Italy	424
England	438
Scotland	463
Ireland	476

Classifying occupations relative to sex, the lecturer stated that the increase in the number of males in the twenty years from 1870 to 1890 for all occupations was 76·40 per cent., and for females 113·19 per cent. Classifying as to great industries, it is found that in agriculture, fisheries, and mining, the males have increased 48·08 per cent., and the females 17·14 per cent. The females have shown a much larger relative increase than the males in professional service and in manufactures. Percentages in all these cases, however, are misleading, because the basis on which they are calculated varies; for instance, the percentage for the large number of males employed in the year 1870 would be less than the percentage for females based on the small number then employed; the relative increase not being well shown by percentages.

The lecturer gave some interesting figures supplementary to those relating to agricultural labor. In 1850 there were in all 1,500,000 farms in the United States; in 1890 there were 4,500,000 farms. In 1850 the total acreage of these farms was 293,500,000 acres; in 1890 it was 623,250,000 acres. It has been claimed that what are known as bonanza farms are on the increase; but statistics show that there is a steady decrease in the size of the average farm.

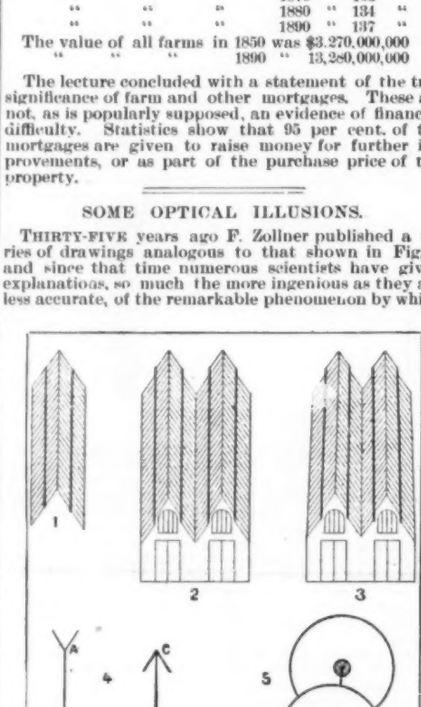
The size of the average farm in	1850	was	203	acres.	
" " "	1860	"	199	"	
" " "	1870	"	163	"	
" " "	1880	"	134	"	
" " "	1890	"	137	"	
The value of all farms in	1850	was	$3,270,000,000		
" " "	1890	"	13,280,000,000		

The lecture concluded with a statement of the true significance of farm and other mortgages. These are not, as is popularly supposed, an evidence of financial difficulty. Statistics show that 95 per cent. of the mortgages are given to raise money for further improvements, or as part of the purchase price of the property.

* Abstract prepared for the SCIENTIFIC AMERICAN by J. B. Walker.

SOME OPTICAL ILLUSIONS.

THIRTY-FIVE years ago F. Zollner published a series of drawings analogous to that shown in Fig. 1, and since that time numerous scientists have given explanations, so much the more ingenious as they are less accurate, of the remarkable phenomenon by which



FIGS. 1, 2, AND 3.—Illusions of Parallel Lines.
FIG. 4.—Illusion as to the Length of Lines.
FIG. 5.—Illusion of Circles.

the two heavy lines of this figure, which are exactly parallel, appear to diverge toward the top.

In Fig. 2 the same phenomenon appears still more distinctly; but here it is no longer an illusion, since the draughtsman has correctly represented a structure of odd form, the most distant part of which is wider than the immediate facade.

An analogous structure, of rectangular form, is represented in Fig. 3, where perspective has been observed. The spectator is right therefore in saying that the lines of Fig. 3 represent parallel ones. Hence it is going but a step to say that they are really parallel, and that consequently the similar lines of Fig. 2 are not, while in reality they are. It is by an involuntary assimilation that we are led to believe that the lines of Fig. 1 are not parallel.

This experiment recalls the misadventure of an artist who, detained by an accident in a country tavern, and finding himself out of money, proposed to settle his bill by painting a sign that represented a stage coach standing in front of the Hotel de la Poste. The tavern keeper, before accepting such payment in kind, sent for the most expert man in the village in point of carriage building. This man, who was a wheelwright, stuck one of the points of a pair of compasses in the center of the hub of the wheel of the stage coach, and, with a sweep of the instrument, described a regular circle which greatly differed from the ellipse drawn by the painter, in sententiously remarking: "That's all I have to say to you." It is unnecessary to say that the sign was refused with disdain. It was useless to explain to the wheelwright that in perspective a circle must be represented by an ellipse, and yet a child, upon looking at the painting, would not have hesitated to say that the wheels appeared round to him, and not oval.

Every picture representing real objects in perspective must alter the dimensions of the lines and their angles. The result is that, being accustomed to look at objects, we are inclined to make rectifications of the images that we receive from them, and the persistence of which explains the Zollner pseudoscopy.

Fig. 4 produces an illusion no less striking. It is necessary to measure them in order to be sure that the lines AB, CD, are exactly equal.

If we look at Fig. 6, we shall find it difficult to believe that the lines ab and cd are perfectly equal, for it is easy to see that the wardrobe is not as high as the room. We beg leave to remark that in this picture the extremities of the line ab end at lines analogous to those that are at the extremities of the line AB of Fig. 4. There is the same analogy between the lines CD and cd of Figs. 4 and 6. Now it would be easy to multiply analogous examples and to remark that when we look at surrounding objects the arrangement AB is often met with in contiguous vertical lines, while the arrangement CD exhibits itself to us only in distant lines, such as ab and ef, of Fig. 6. Therefore, in our need to know the real dimensions and not the apparent size of objects, we get into the habit of estimating the lines of the system CD to be longer than those of AB, and we preserve this habit after its raison d'etre ceases to exist, for example, when we look at Fig. 4.

Dr. Green, of St. Louis, Mo., has made known a pretty illusion furnished by Fig. 5. The upper circle appears to be larger than the lower one, and the explanation is analogous to the preceding.

One cannot help thinking that the image represents two paper disks into which has been stuck a pin serving as an axle to two wheels, which, if they were equal, ought to be figured unequal in the sketch. This experiment of Green is still more striking when, instead of one drawing, we make two designed to be viewed in a stereoscope.

All the optical illusions that have just been considered and other analogous ones appear to us to be explained thus:

When lines drawn upon a plane have arrangements analogous to those that the eye is accustomed to meet with in the perspective representation of objects, the appreciation of the dimensions and positions of such lines is perverted by the interpretation habitually evoked by lines thus arranged.—La Nature.

THE MANUFACTURE OF UNITED STATES POSTAGE STAMPS.

PROBABLY you have noticed that, no matter how frozen up things are this winter, your postage stamps remain in perfect condition for sticking, without a crack or any of those disagreeable "bare spots" that have heretofore often characterized the mid-winter output of stamps.

But, likewise, probably not one in all the millions of people who are daily using postage stamps know, or have even stopped to wonder, why this is the case.

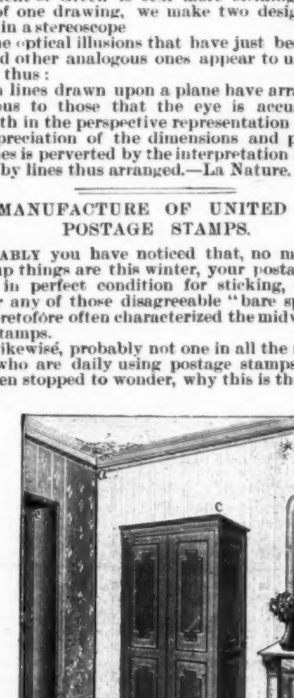


FIG. 6.—Illusion of Vertical Lines.

In fact, the reason was learned only casually the other day during a visit by a Boston Herald correspondent to the new stamp division of the Bureau of Engraving and Printing, where tremendous progress has been made by Uncle Sam's experts in spite of serious hindrances thrown in the way by the former contractors.

It was in learning of these difficulties and of the final triumph over them, and of the marvelous skill so quickly attained in supplying the enormous demand for postage stamps, that the striking fact of changing the process to suit the seasons was brought out, among others. Just how and when this process occurs so as to give us winter stamps in winter and summer stamps in summer will be explained in detail a little further on.

To have a clear notion of the mechanical marvels and complex processes employed for the production of so simple an article of public use as a postage stamp will be worth the while of every intelligent reader. To begin with, we must examine the paper used in the production of stamps. Unlike the paper used for money, there is no distinctive characteristic about the paper on which postage stamps are printed. It is merely first class wood fiber paper, with the government's water mark, "U. S. P. S." repeated again and again on its face to render difficult its counterfeiting. The counterfeiting of stamps is, however, a rare crime; probably because "the game is scarcely worth the candle," from a financial point of view. The offering of postage stamps at reduced rates or even at regular rates in large numbers by private individuals would be pretty sure to arouse suspicion, which would end in trouble for the counterfeiters. A theft of a few hundred dollars' worth of stamps printed at the Bureau of Engraving and Printing soon after the government began to make the stamps was an experiment in criminality which resulted in the prompt capture and conviction of the thieves, who are now serving good long sentences.

The paper is made for the government under contract at Lock Haven, Pa., and from the time it quits the state of pulp in the vats of the paper mill until it issues from the stamp windows of the thousands of post offices throughout the country, is guarded by the most careful watchfulness. Automatic counting machines at the paper mills keep accurate account of each sheet manufactured. A government inspector

looks after the counting machine and certifies its accuracy to the Treasury Department.

Eventually, under a strong safeguard, the paper reaches the loan division of the Treasury Department, and from here the Bureau of Engraving and Printing receives its daily supplies, giving each time a provisional receipt for the number of sheets taken, and a final receipt when each particular installment of paper is counted at the bureau. There is scarcely ever a variation between the Treasury count and the count of the bureau. After the paper is received at the bureau and is started in the process of stamp making it has countings galore; when it is ready to issue forth in red and blue and brown and green stamps, it has had no less than fifty-two separate and distinct countings.

It should be stated here that when the Bureau of Engraving and Printing makes a requisition on the loan division of the Treasury Department for stamp paper it must state specifically what is to be printed on the paper. If the bureau gets 10,000 sheets of paper to print two cent stamps, it must account to the Treasury Department for 10,000 sheets of two cent stamps, less, of course, the number actually spoiled in the different processes; and the spoiled sheets must also be in evidence, and no eloquence that has yet been invented can otherwise explain any discrepancy.

The moment paper for stamps of a designated denomination leaves the Treasury Department it becomes worth on the books of the department just the amount of the stamps of the given denomination that can be printed upon it. The transfer of the paper from the Treasury to the Bureau of Engraving and Printing is made in ironbound chests, which are placed in great vans lined with chilled steel and carefully guarded. At closing time at the bureau no employe is allowed to leave the building until the last particle of paper, printed or unprinted, and the last plate and die are accounted for, nor is any employe permitted to depart before closing time without a pass from the chief of his or her room, approved by the chief of the bureau.

At the bureau the paper is first taken in hand for the "wetting down" process, with a counting, on entrance, known as the "dry count." This wetting down process consists simply of placing dampened cloths between each batch of about twenty sheets of paper, which is afterward placed under great weights, to allow the moisture to permeate the sheets evenly, and to further this end, after thousands of these batches are thus wet down for a brief season, the weights are removed and each batch is evenly divided and reversed, putting the outer and damper sides which have lain next to the cloths inward, so that the moisture may be still further distributed. Each process is accompanied by a count of the sheets, so that when the paper emerges from this preliminary treatment it has been counted sheet by sheet four times, and has already had the ministrations of a small army of "wetters," "driers," "counters," "pressers" and "cloth wringers," though it is only fairly started on its course. From two to four days are given to the wetting process, according to the urgency of the demands of the printers. Then the paper goes to the printing division, and receipts for it are passed to the last handlers. Here another count or so occurs, and here is demonstrated the best use Uncle Sam has yet discovered for counts and countesses—who can count.

The process of printing does not differ in method from the printing of bank notes. The presses are propelled by steam, and each press carries what a letterpress printer would call four "forms," which travel horizontally in what might be called a "square circuit" on endless chain belts, before the printer and his assistants, who comprise the working force of each press. The forms follow each other with monotonous regularity from the point of contact with the inking mechanism to come next in contact with a mechanism which wipes off the surplus ink, next to the hand of the printer, who, with his bare palm covered with whiting, rubs off the still existing excess of ink, and at the same time polishes clean and bright for each impression the parts of the plate which are not intended to print—nothing has yet been invented for this purpose that can equal the human hand, and it must be done so skillfully as to leave not too much nor too little on the plate, but just enough to make a clean, strong impression. Then the plate passes on and the impression is taken; as it emerges another plate passes to its impression, and so on at the rate of about 2,500 impressions, or about 100,000 stamps, an hour.

Each printer has two girl assistants—one to put on the sheets and one to take them off, so that he is free to devote all his time to polishing the fast traveling plates, as one after another presents itself before him with a momentary pause.

Stamps are printed in sheets of 400 stamps or "heads," as they are called at the bureau, and, as each press carries four plates, it will be seen that one revolution of the press means 1,600 stamps. The dies from which these stamp plates are made are on soft steel and made by the bureau's engravers. They are hardened and an impression of them is taken on a roll of soft steel, which, so far as lines go, is just the reverse of the dies. By this means the sunken lines on the dies become the raised lines on the roll, just as if you were to take a piece of chewing gum and impress a penny into it; but the next step makes it all right again. After the reverse impression has been made on the roll it in turn is hardened and rolled back and forth over a big plate of fine, soft steel until it cuts its impression clear and sharp as many times as it is desired that the plate shall contain stamp dies. Then the big plate is hardened, and it is ready for the printing process; the impressions on the stamps are made from depressed lines filled with ink.

A plate containing 400 stamps is about 2 × 2½ feet in size, and will last a great while. If you have ever bought a full sheet of stamps and wondered what was meant by the mystical numbers on the lower margin, you will be interested to know that this is the printer's plate number, and you will recall that by this number the printer and his assistants are charged with every sheet of damp paper they handle, and that this number is credited with every sheet of stamps, perfect or imperfect, that they return, and one must always agree with the other.

As the sheets come damp from the press they are packed up in stacks, a sheet of tissue paper between each sheet of stamps, and after more counting and passing of receipts, are taken to another division, where they are placed in small batches with wire-bottomed trays, and where a series of electrically propelled fans keep the air continually in motion.

In about twelve hours they are dry of ink and moisture. Then deft fingered girls take them in large bundles, laying one hand in the middle of the sheets, and turn with incredible rapidity sheet after sheet. The impression made upon the visitor is that they are counting them and counting at a furious rate, too; and so they are, but they are keenly and critically examining the sheets at the same time for all imperfections. When a sheet is found with any sort of imperfection the rustling of the sheets ceases long enough for them to withdraw the sheet, mark it with a hasty scrawl, which to the uninitiated means nothing on earth, but to the stamp people is quite a full critique of the sheet's shortcomings; then the restless rustle proceeds as before.

This is the only division of the bureau where they do things "by halves" and accomplish the best results. One examiner examines only the left hand sides of the sheets and passes them to another, who examines the right hand sides. Thus the eye is relieved of too big a range of scrutiny to be reliable, and a count and a verification are at the same time accomplished.

Probably the most interesting of all the details of stamp making is the process of applying the adhesive gum, and it is one here reduced to such perfection that the bureau people may be pardoned for the pride they have in it. Right here, indeed, lies the heart secret of successful stamp manufacture. The process of gumming was always a secret carefully guarded by the former makers of the stamps. There is no longer any mystery about the clean and adequate process the Bureau of Engraving and Printing was forced to invent.

The gumming division is a big apartment in the basement of the building. The greatest care is taken to keep the temperature of this room evenly at 80 degrees, summer and winter. This temperature corresponds to the temperature of the gum as it is applied to the stamps. Even greater care is taken to keep the average humidity at about 50, which is just midway between the humidity of a damp, drizzly day and a crisp, bright one. So much importance is attached to this atmospheric condition in the gumming of stamps that six humidity tests are made during the seven hours which constitute the working day of the bureau—at nine, ten, and half-past eleven in the forenoon, and at one, two and three in the afternoon.

A careful record of these readings is kept, so that it would be possible for the chief of the division by referring to it months and years afterward, to tell just what weather conditions he had in gumming a particular output of stamps. Apparatus is provided to correct any tendency to undue dryness brought about by the weather conditions outside the building.

The gum is made of equal parts of dextrine, which is a starchy derivative of the potato, and of "Caldwell gum," much like the dextrine; the last named being made in Scotland and imported for the government's use. To these are added a per cent. of glucose, the amount being conditional upon whether the stamps in process of gumming are to be used in cool weather or hot. The glucose is contributed to harden the gum and make it less liable to stick when it shouldn't or run off in streaks. The stamp product of these winter days needs but a very small amount of it, because the cool weather is a sufficient protection against undue softness, but later in the year, when the bureau begins to turn out the summer supply of stamps, more of it will be added to make them stand the hot spell. This gum is clean and wholesome, and stamp lickers need apprehend no injury from an indefinite amount of licking. Six or seven hundred pounds of the ingredients referred to are put into a big caldron with a quantity of water, and after it has boiled an hour or more it is drawn off into smaller tanks. Now comes an expert in stamp gum with his hydrometer, which is merely a glass tube with a scale on one end and a bulb on the other filled with shot. This he drops into the tank of gum; if it sinks to a mark on the scale which has been determined as the indicator of the proper consistency of stamp gum, it is just right; if it sinks lower or not so low, it is too thin or too thick, and is doctored accordingly. When the paste is indicated to be all right for use the next step is the application of it to the stamps, but even here the scientific accuracy of the process is maintained—actually every particle of the gum applied to stamps is weighed, the allowance being made of twenty-five pounds of gum for every 400,000 stamps.

The gumming machines are marvels of ingenuity. From a fountain which receives the gum after it has been tested and weighed a brown stream of gum flows evenly into a rectangular reservoir, which rests against a fast revolving roller accurately made of ground glass; the slightly rough surface of this roller takes up the gum and applies it to the backs of the stamp sheets as they pass under it on an endless carriage provided with grippers and fingers that operate in the most lifelike way. Sheet after sheet passes face down under this gumming roller speeding along on its endless carriage, and then it enters a long chest and throwing a parting shimmer of its newly gummed surface in a mirror placed just above the entrance to the long chest, which reminds one of an incubator on a big scale.

This particular shimmer is not altogether a poetical incident of the process, nor is the mirror intended exclusively for the gratification of the young lady operator. With her back to the light the operator catches the reflection of the shimmer in the mirror as the sheet recedes from her, and by this means can tell whether the gum is being applied evenly. So, after throwing its farewell gleam to the pretty girl gummer, the sheet of stamps passes into the incubator-like chest, which is kept full of hot dry air, and when it emerges it is dumped on the tables of other girl operatives at the other end, after a journey of sixty feet in a temperature of 132 degrees and is quite dry and ready to be smoothed of its slight crinkles and packed for delivery to the perforators, who separate by machinery each original sheet into four such sheets as are delivered to the post office, cutting at the same time the perforations which enable them to be easily separated; and finally, hydraulic presses remove the "burring" left by the perforating machines.

THE MUSIC OF NIAGARA.

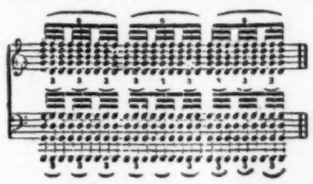
MR. EUGENE THAYER, the well known organist, has published an analysis of the music of Niagara Falls. He says: "It had ever been my belief that Niagara had not been heard as it should be, and in this belief I turned my steps hitherward. What did I hear? The roar of Niagara? I heard nothing but a perfectly constructed musical tone, clear, definite, and unapproachable in its majestic perfection, a complete series of tones, all uniting in one grand and noble unison as in the organ. I propose to give much more than the pitch of this tone. All the accessory or upper tones, otherwise known as harmonic, collateral, or overtones: also the rhythmical vibrations and subdivisions, from the largest to the smallest."

Mr. Thayer then describes at some length the compound nature of a given tone, and illustrates the overtones or partials of the lowest C of the thirty-two foot pipe of the organ. Then he continues:

"I had long had a suspicion that I should hear all this at Niagara when her wonderful voice should first greet my ears. It was just as I had supposed. How should I prove all this? My first step was to visit the beautiful Iris Island, otherwise known as Goat Island. My next step was to stand on Luna Island, above the Central Fall, and on the west side of the American Fall proper. I went to the extreme eastern side of the island in order to get the full force of the larger fall. I then went over to the Horseshoe Fall and sat among the rapids. Next I went to the Three Sisters Island.

"I next experimented on the east side of the American Fall both above and below Prospect Park; then on the Canada side of the great Horseshoe—above, below, and midway; then in midstream below both falls; then at the Upper Suspension Bridge; then at the lower or railroad bridge; once at Schlosser Island, above the Upper Rapids, and finally all the way down the Lower Rapids to the Whirlpool. With more or less variation of pitch at the various points, I heard everywhere the notes of the chord of G, only four octaves lower.

"I arrived at my conclusion, both theoretically and practically. Let me first call attention to the third and fourth notes, d, g, in the diagram. The ground



tone, G, was so deep, so grand, so mighty, that I never could realize it, or take it into my thought or hearing; but these two tones, only four octaves lower, were everywhere, with a power which made itself felt as well as heard. But it will be replied, these two notes were too low to be detected by the sense of hearing. How did you determine their pitch? I first caught the harmonic tones above them that were definite in pitch, and then counting the number of vibrations of these lower two notes, easily determined their distance below. And here comes a curious feature which proves that Niagara gives a tone, and not a roar. The seventh note (diagram), the interval of the tenth, was of a power and clearness entirely out of proportion to the harmonics as usually heard in the organ. Were the tone of Niagara a mere noise, this seventh note would be either weak and confused or absent altogether. Here it was clear and perfect, and extremely pleasing in effect. What is Niagara's rhythm? Its beat is just once per second. Here is our unit of time—the chronometer of God."—Trinity Record.

DR. HAFFKINE AND CHOLERA.

DR. HAFFKINE, whose recent campaign against cholera, says the London Times, forms so brilliant an episode in the medical history of Bengal, has, after a Christmas visit to England, returned to the Pasteur Institute, Paris. That campaign we have already described. This morning we deal with the more personal aspects of his work. Waldemar Mordecai Wolff Haffkine was born in 1860, in a Jewish family of good position in South Russia. After a distinguished youth in the Gymnasium of Berdiansk and the University of Odessa, he found himself, at the age of 23, a doctor of science, but practically precluded by his birth from the higher academic career in Russia. The Natural Society of Odessa, however, marked their sense of his rare promise by providing a biological laboratory for his special use. He justified their generosity by five years of masterly research. In 1888 he passed on to the Geneva University as assistant professor of physiology, and in 1889 he found his true place in life as an assistant to Pasteur.

His early studies were directed to the laws of propagation in the lower fungi, algæ, and especially in the paramoccia. He then took up the infectious diseases to which such microscopic organisms are themselves subject from invasion by other microbes of still smaller size. He demonstrated that any sudden change in the media, whether for better or for worse, sufficed not only to arrest the multiplication of infectious microbes, but to kill them. On the other hand, a gradual acclimatization of microbes to the most deleterious media could be effected. Dr. Haffkine succeeded in obtaining forms which produced typhoid and cholera by inoculation in the lower animals hitherto immune, and he thus brought the etiology of those diseases within the domain of laboratory research. At the same time he developed forms which proved destructive of the original microbe.

The vaccines used by Dr. Haffkine for his 42,445 human inoculations in Bengal were derived from the cholera microbe discovered by Dr. Koch eleven years ago. Certain of the Calcutta bacteriologists had been unable to accept Dr. Koch's conclusions. The study of the cholera epidemics in France, Italy, Germany, Austria, Russia, and Spain, subsequent to Dr Koch's researches in India, brought conviction to the scientific mind of Europe. The comma bacillus migrated simultaneously with and in lines parallel to the movements of the disease across a continent 5,000 miles from

its Asiatic home. Yet Calcutta itself affords a field of observation scarcely less decisive, although in a different way. Dr. Haffkine found the municipal water supply, drawn through filter beds from the Hugli River, to be invariably free from cholera germs, whether the particular quarter of the town in which the hydrants were tapped was suffering from cholera or not. Nor could those germs be detected in the air of stifling huts in which deaths from cholera had taken place, nor on earthen floors from which a corpse had just been removed. But a striking connection appeared between cholera and the microbial flora of the drinking ponds. In over 91 per cent. of the drinking ponds examined in localities infected with cholera the comma bacilli were present; in over 81 per cent. of the ponds examined in localities free from cholera they were absent; while in none of the drinking ponds in localities which had suffered from cholera six weeks previously, but had got rid of it for that period, was the comma bacillus found.

Dr. Haffkine speaks with gratitude of the kindness shown to him by the medical service in India. The fact of the natives claiming the principle of preventive inoculation as their own discovery, long before it was known in Europe, also served him in good stead. "The whole population," he said to a friend, "had a definite idea of the possibility of preventing diseases by the same methods which for centuries had been in use among themselves." Dr. Haffkine has accomplished his beneficent work for the British Army in India not only at his own cost, but at the sacrifice of his health. He is for the moment a wreck from persistently neglected fever. He proposes to start again for Bengal next March to complete his self-appointed task. But we sincerely hope that he will defer his departure until he has thoroughly recruited his health. India, or rather the disregard of the timely warnings which India gives in the form of fever, cost Europe one of her most brilliant scholars in the first half of the century. The fate of Csoma de Körös stands as a beacon against tempting Providence by like acts of heroic indifference.

RELATIONS OF GEOLOGIC SCIENCE TO EDUCATION.*

By N. S. SHALER.

THE author has been in good part led to take up this subject for the reasons that the title itself is a protest against the modern notion that the work of research should be separated from that of teaching, that natural inquiry should be released from the ancient and profitable connection with education. Undoubtedly a certain kind of success would attend the complete separation of the students of phenomena from those whose business it is to impart knowledge, but there are gains which, though immediate, are not desirable, for the reason that in the long run they entail serious losses. It seems to me that the explorer, if he be animated by the true spirit of his class, finds himself seeking for undiscovered realms, not for personal gains, nor, indeed, merely to add to the store of things known, but always with reference to the enlargement of mankind. His motive is in the highest sense that of the teacher, but the opportunities of sympathetic contact with his fellow men which are to be had through the press and the learned societies are very limited and are quite insufficient to satisfy the natural desire of an ardent student of nature for relations with the life about him. The teaching function of the master of science is of the utmost importance to that science. We all recognize and deplore the evils which arise from the fact that young people have to be introduced to most branches of learning by teachers who have little chance to gain or to preserve the spirit of inquiry. If men are to be bred in the ways of the naturalist, the task must be done by investigators, but inquiry and instruction must be combined so as to give the men of science time for their studies as well as an opportunity to influence youths by their teachings.

It is more important that this connection between research and instruction should be preserved in geology than in the other natural sciences. In chemistry and physics the subject matter is brought into the laboratory, but in geology only a very small part of the fact can be demonstrated by laboratory means. A capital instance of what can be done by a teacher who is also an inquirer is afforded by the work of Louis Agassiz in extending the interest in glacial geology in this country. His lectures on the subject were so vivid, they so effectively presented the physiognomy of the Swiss glaciers, that they quickened the imaginations of the dullest persons. They aroused an interest in the matter which was so intense and on the whole so well informed that the study of glacial geology in the larger sense of the term developed more rapidly and on better lines in this country, where existing ice fields are lacking, than in European lands, where examples abound. In such work we see the part of the master in instruction.

Assuming, as we needs must, that as geologists it is our duty not only to extend the learning of the science, but also to take charge of its diffusion among the people, let us consider in general the value of good which we have to deliver and the manner in which the transmission may best be effected. In the first place we should note well the fact that geology is not limited to a particular group of facts or modes of energy, but is in a way concerned with nearly all the work which is done in and on this sphere. It should be in its province, as it is clearly in its power, to give to mankind perspectives which will serve vastly to enlarge the evident field of human action. No true success in education is possible until we contrive an awakening of the youth from the sleepy acceptance of the world about him. The story of the ages clearly told, with a constant reference to the bearing of the matter on the appearance and the fate of man, will quicken any mind that is at all fitted to profit by the higher education. While many things go into the making of the world's judgments, there can be no question that the plain truths concerning the antiquity of the earth and the series of events which have led to the coming of mankind have in this generation been most effective in overturning sectarian bigotry and in other ways enlarging the spirit of man.

It is necessary distinctly to separate the body of the instruction which is to be given in geology into two parts—that which is appropriate to the general public and that which fits the appetite of the professionally minded. First of all, interest in the subject must be aroused, and the experience of the author for nearly a third of a century, and with more than 4,000 students, leads him to say: That instruction in geology which is meant for those who have not acquired the professional motive must find its basis of interest on either of two foundations—on the element of sympathy with all which relates to the fate of man, which is native in all of us, or on the love of the open fields which every youth who is not supercivilized has as a birthright. In treating of volcanoes, the very humanized story of Vesuvius or of Aetna, especially the dramatic episode of the death of Pliny the Elder, is worth much to the teachers for the reason that it serves to bring a sense of human affairs into a subject which for lack of illustration is apt to remain remote and therefore uninteresting.

As soon as the teacher, through his work in the lecture room, has succeeded in extending the natural, inborn interests of his pupils to the problems of geology, instruction in the field should begin. Here direct instruction should largely cease, for the true use of the field is to awaken in the pupils the habit of seeking for themselves. The teacher may trust in this task to the existence of an observant motive in men which is at its best when they are in the open air. The observing faculties of the pupils, however, may be much assisted and sharpened by means of skillful questioning by the teacher. Great stress must be laid on the countless phenomena which will lead the youth to conceive the earth about them as a realm of continuous processes and not as a finished, dead entity.

The hindrances to success in field teaching are protean in form, but they are most commonly to be found in an inability to think in three dimensions and in an incapacity to continue any work when alone. These are largely due to supercivilization. The first trouble may sometimes be remedied, but the inability to work alone in the field is a rather common and, in the author's experience, an incurable defect in certain students who would otherwise be fitted for geology.

In the department of Harvard University which is devoted to the science, about 300 each year enter on the elementary work. Of these not more than the eighth part continues the study to the point where they may begin to do work which may be regarded as independent; yet fewer essay the training which looks forward to a professional career. This indicates that geology in the larger sense of the term is an interest for a few chosen spirits who are so fortunate as to be born with a share of the world sense, or at least with an aptitude for studies which demand a measure of the primitive man which is not to be found in the most of our supercivilized folk.

In the demand which is now made for a beginning of all our sciences in the secondary schools it is proposed to include geology in the list and to set boys and girls of from fourteen to seventeen years of age at work upon the elementary work of the learning. For my own part, while it seems to me that some general notions concerning the history of the earth may very well be given to children, and this as information, it is futile to essay any study in this science which is intended to make avail of the larger educative influences of the science with immature youths. The educative value of geology depends upon an ability to deal with the large conceptions of space, time and the series of developments of energy which can only be compassed by mature minds. Immature youths, even if they intend to win the utmost profit from geology, would be better occupied in studying the elementary tangible facts of those sciences such as chemistry, physics or biology, sciences which in their synthesis constitute geology, rather than in a vain endeavor to deal in an immediate way with a learning which in a good measure to be profitable has to be approached with a well developed mind. The very fact that any considerable geological problem is likely to involve in its discussion some knowledge of physics, chemistry, zoology and botany is sufficient reason for postponing the study until the pupil is nearly adult.

In the interests of geology as a science it is most desirable that all expert work should pass into the hands of a body of men who should bring to their task so much of geology as is needed for the particular inquiry, commonly not very much, and who can join with it the more important practical acquaintance with the miner's art and the conditions of trade which relate thereto. In certain cases the men of theory may well serve these experts. All their inquiries are likely to be of service in the determinations, but on them should not be the responsibility for the business side of the problems. There is little the geologist does in the way of research which may not have some practical application to the affairs of men, but he should not mistake this possibility of usefulness as an indication that it is for him to give his inquiries an economic turn.

Geological science, like the most of the other branches of natural learning, has two distinct points of contact with society—that of instruction and that of economic affairs. In each of these fields of usefulness its services to man have been great and are to be far greater in the time to come. As for instruction, the task is to give to men an adequate perspective for their lives. It is to ennoble our existence by showing how it rests upon the order of the ages. In the economic field it is to show the resources which these ages have accumulated in the earth for the service of the enlarged man, who is to attain his possibilities by a full understanding of his place in nature. To do the fit work we need to combine the functions of explorers and guides zealous to open the way to the unknown, and those of teachers who take care that the youth of our time are led into the land which we know to have so much promise for man.

* Presidential address delivered to the Geological Society of America at its annual meeting in Philadelphia, December 27, 1895. Abstract prepared by E. O. Hovey for the SCIENTIFIC AMERICAN.

JOHANNESBURG, SOUTH AFRICA, presents a present field of wealth to the makers of gold mining machinery and plant. Forty-stamp mills, of about 7,000 tons crushing power per month, appear to be the general run of crushing machinery erected at the newer gold mines in the Johannesburg district, but many of the older establishments, where the development has proceeded farther, have 100 to 160. Everywhere large expenditure is being incurred in winding and hauling machinery, and plants already erected are being extended all over the Rand. At the new Primrose mine, Johannesburg, machinery equipment is of the first order. The mill engines have been altered to triple expansion, to cope with the increased output, and 160 stamps are in operation. The crushing at this mine amounts to 25,000 tons of gold quartz per month, and its development is gaining on the crushing mill power to the extent of 2,000 tons per month. The management are considering the advisability of erecting forty more stamps, which would raise the crushing mill power to 32,000 tons per month.—Mining and Scientific Press.

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